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Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

H. Armstrong Roberts.

Millions for Fire Defense.
How Much for Fire Prevention?

The Quarterly

Vol. 24 October, 1930 No. 2

Perpetuating the Country Circus. In the old, less sophisticated, days the small boy in a country town rejoiced at the coming of a circus, but the merchants didn't like it. It took money out of town and people paid cash for circus tickets who owed money to the grocer. The burning of property in our towns and cities is a kind of continuous circus that steadily depletes our treasuries, individual and collective. The only difference is that the circus gives something back. The fire waste is a total loss. A fire department tearing through our traffic-choked streets to extinguish easily preventable fires is a kind of circus spectacle. It involves more danger to life and limb than a trapeze performance, and the cost of the tented circus is a bagatelle in comparison. Our fire departments are already larger and more costly than they should be and their expense is steadily mounting. As our cities grow, the fire departments grow, and the water resources for fire extinguishment grow in both size and expense. The cost of municipal fire safety, a safety which we assume we have but have not, is the sum of the water cost, the fire department cost, and the fire insurance cost.

The common city attitude of mind is fire extinguishment, not fire prevention. Millions for fire defense but reluctantly one cent for fire prevention. Our national fire loss of $500,000,000 per year is the answer to this attitude of mind. It is time we applied enough intelligence to this problem to find out how we are heading. In every other major problem we are dealing with causes instead of effects.

The United States Chamber of Commerce has created a fire waste council. This council has organized an annual contest for a prize in fire prevention leadership. The object of this effort is to stimulate in American cities the idea that fire prevention is a business proposition. What kind of business is it that keeps no books; that doesn't know what it is paying for its commodities; that is too thoughtlessly conducted even to reveal the elements that should make up its balance sheet? Is there a single American city that knows what its fire waste is costing it? There is not. There is scarcely a city that even knows what its major fire causes are and is moving to correct them. The

huge and bewildering costs of fire defense and rehabilitation have never yet been considered as a business proposition. The thought that these costs can be easily, positively and systematically reduced has not yet penetrated the minds of the leaders of commerce in our cities. Chambers of Commerce are appropriating funds to attract new industries to their cities without any investigation or mention of what they have to offer in this vital matter of fire safety or fire costs, and yet the attitude of every city toward fire safety is obviously written into its insurance rates. If uninterrupted production or marketing processes in business is desirable no new enterprise should be persuaded to locate in a city oblivious to its fire hazards. Anybody who would like to serve his city or country in an almost untouched field of research and adventure will find here a subject that will disclose ineptitudes in our American life almost unbelievable of a people credited with active intelligence.

* * * * *

Fire Prevention and Business Conditions. In the present business depression unusual attention is given to statistics showing the trend of business conditions with all eyes watching for definite signs of business revival. In this connection the distribution of N.F.P.A. Fire Prevention Week posters may be considered an index of some interest.

Anticipating that Chambers of Commerce and other civic organizations which usually purchase N.F.P.A. Fire Prevention Week posters for general distribution would have less funds available this year, the N.F.P.A. Executive Office reduced its initial order for Fire Prevention Week posters to a little more than half the 1929 distribution. The initial edition, however, was exhausted early in September and a second edition was necessary. The total distribution materially surpassed the similar figure for 1929, which in turn had been much in excess of 1928.

The increase in the distribution of N.F.P.A. Fire Prevention Week posters, which incidentally applies as well to other items of campaign literature, may perhaps be indicative of some betterment in business conditions. Be this as it may, we have in these increased N.F.P.A. Fire Prevention Week poster sales positive evidence that Chambers of Commerce and other civic organizations are now so thoroughly "sold" on the importance of systematic fire prevention campaign activities that these are carried on without curtailment in this year of general depression.

* * * * *

The Fire Loss Trend. The fire loss for the first eight months of 1930 was $313,191,165 as compared with $292,525,181 for the same period in 1929. This represents an increase of seven per cent. An analysis of the reports received indicates that the increase in loss over 1929 has not been due to any great increase in the number of fires, nor to any major conflagration, but rather to an increase in the number of large loss fires.

The following table shows the losses in detail by months for the two years.

	1929	1930
January	$44,713,825	$42,847,000
February	41,520,290	43,206,940
March	41,277,814	42,964,392
April	36,845,795	43,550,996
May	32,129,408	38,415,142
June	33,605,663	31,818,266
July	31,985,493	34,847,750
August	30,446,893	36,043,679
Total 8 months	$292,525,181	$313,191,165
September	29,249,355	.....
October	31,652,385	.....
November	29,061,860	.....
December	39,215,338	.....
Total 12 months	$422,215,128	.....

The losses for 1929 and 1930, as reported by the National Board of Fire Underwriters, are not readily comparable with the figures for the previous years, as these monthly estimates compiled by the National Board of Fire Underwriters were not available prior to 1929. Before that the estimates of the New York *Journal of Commerce* were the general criterion of the fire loss trend pending the publication of the final loss figures by the National Board of Fire Underwriters. It would appear from these previous figures, although prepared on a different basis and not strictly comparable, that despite the increase in the fire loss of 1930 over 1929 the loss this year is somewhat under the average of the preceding five years. The increase in the loss in the present year may be considered on this basis as a temporary fluctuation rather than as indicative of any permanent upward trend in the fire losses.

Explanations of the present rise in the fire loss curve lead to interesting speculations. At first glance there appears to be a direct relation between the business depression and the increased fire losses, thus giving support to the viewpoint held by many fire authorities that a very substantial proportion of the total fire losses are in the "moral hazard" class. It is frequently pointed out that in times of business depression there is not only an additional incentive to the incendiary, but also that so-called unconscious incendiarism plays an important part when business is not profitable. Attention to housekeeping and fire protection upkeep is relaxed with resultant increase in the fire loss.

Statistics from another source, however, do not support this conclusion. The New York Board of Fire Underwriters estimates the losses in New York City area at $7,009,272 for the first eight months of 1930 as compared with $8,788,859 for the similar period in 1929. This represents a decrease of twenty per cent. New York City presents a sufficiently large volume of expe-

rience so that the figures should not be susceptible to material distortion by a single large loss fire and should in theory reflect the influence which business conditions have upon the fire loss. Whatever the explanation for the decrease in fire loss in New York, the difference in trend between the New York City figures and those for the entire United States is marked and shows clearly that in New York City at least the business depression has not involved an increased fire loss. The inference is that some influence other than business conditions must be sought in explaining the increased national losses.

* * * * *

The Drought and the Fire Loss. The year 1930 has been a period of unprecedentedly small rainfall. The entire country has suffered, some sections more than others, but the situation has been such as to cause national concern. Many students of fire losses feel that there is a direct relationship between weather conditions and the fire loss curve and it seems probable that the drought of 1930 may be a major influence in the increased fire losses of this year.

The influence of weather conditions is shown most clearly in forest fires. Combustible material of the forest is peculiarly susceptible to ignition when thoroughly dry, whereas after a protracted wet period the danger of forest fires is negligible. Not only does humidity affect the susceptibility to ignition, but it affects the rate of burning of a fire that is once started. The same thing applies to a greater or less extent to fires in general. The wooden shingle roof hazard is aggravated in periods of drought. The conflagration in Nashua, N. H., in April, 1930, was largely a wooden shingle roof fire which seems to have been augmented by weather conditions. In respect to other fire causes the relationship between the weather and fire loss may not be so obvious, but it seems clear that any ordinary combustible material is more susceptible to ignition when thoroughly dry, and this fact is doubtless registered in the national fire loss statistics.

It appears that the present drought may affect fire protection for some time in the future, owing to the depletion of water supplies. Adequate fire protection calls for large reserves of water for fire fighting purposes, and in the present depleted condition of water supplies these reserves are in many cases not available. The situation is most acute in the small towns and particularly so in the farming communities, where the only water available for fire protection is taken from ponds, streams and wells, and where there is no reserve of water available for fire fighting. The same situation applies to a greater or less degree in the larger cities, however, and will be a cause of concern to fire protection authorities until such time as protracted rains bring the supply back to normal.

It is said that a year of deficient rainfall may affect water supplies for a period of years. Ground water levels are lowered during a dry period, the flow

of springs and streams and wells is decreased, and it may be a matter of years before the ground water level is restored. It is said on good authority that the present low water in some sections is due in part to the influence of the year 1925, when rainfall was seriously deficient in some parts of the country. The theory is that in that year ground water supplies were lowered and that there has not been sufficient rainfall in the intervening years to make up the deficiency. The country will be fortunate indeed if during this period no major conflagration losses occur due to inadequate water supplies.

* * * * *

Loss of Life in Mine Fires. In analyzing the total loss of life by fire a common error is to consider only the loss of life by fire in buildings, those due to burns from bonfires, etc. There are, however, a large number of casualties from fires and explosions in other locations which are of just as much interest to the fire protection fraternity and which should be considered as part of our problem on the same basis with the casualties due to fires in buildings. We may include in these classes such fires and explosions as those occurring in airplanes, automobiles, boats, mines, etc. These casualties are ordinarily classified as due to airplane accidents, automobile accidents, etc., and it is difficult to secure any data as to the number of casualties which are due directly or indirectly to fire. In respect to mine accidents, however, we have detailed statistics compiled by the U. S. Bureau of Mines which show clearly the extent of the fire and explosion hazard. Figures for the year 1928 have just been released by the Bureau of Mines. Included in the casualties classified as due to mine fires and due to local and major explosions of gas and coal dust, but excluding the casualties due to explosives which should not be classified as fire casualties, we find that in the year 1928 there were 378 men killed. No complete statistics are available on injuries, but it seems probable that the injury figures if available would be even larger than this.

Miniature Golf Courses.

By Gorham Dana,
(Member N.F.P.A.).

Miniature, Pony or Tom Thumb golf has suddenly become the rage throughout the country. A recent estimate by the Department of Commerce gives the number of courses now in use as 25,000 and the amount invested as $125,000,000, this being on an average of $5000 per course. It is said that some courses have fully paid for themselves in a few weeks, so great has been the public interest. Gross income is said to vary from $1000 to $10,000 a month in season. One of the large companies installing these courses gives the cost of material used in the construction of a nine-hole course as $2000, F.O.B. Rochester, Pa. While the majority of courses are out of doors, the indoor courses are also being developed, especially in anticipation of cold weather.

The subject is of interest to the insurance companies and town planner for several reasons: fire hazard, congestion hazard, nuisance hazard and problems of location. One of the insurance companies recently advertised a policy covering fire, lightning, cyclone, tornado, wind storm, flood, earthquake, breakage and peril of transportation at a rate of 2%, but with a minimum charge of $25.

The fire hazard of outdoor courses seems to be practically nil. The materials used in construction are mostly steel and wood, and the fairways are the only points of special interest. Here a variety of material is used, some of which is of a combustible nature. Ground cotton seed hulls dyed green are used by one company for this purpose. The material is shipped in barrels, and if enough cotton seed oil remains in the hulls they are somewhat subject to spontaneous heating, especially when wet.

For indoor courses, a felt made of goat hair on a burlap base is used for these fairways by one company. Another material is a felting composition of some vegetable fiber which, while not very combustible, has a property of glowing like a slow match. This might cause trouble from carelessly dropped cigarettes. Crepe rubber, although expensive, is sometimes used and would appear to be entirely safe. Sweeping compounds have also been used, these being composed generally of sawdust, sand and oils. In this case care should be taken to select only those listed by Underwriters' Laboratories as "slow burning."

The Department of Commerce has also estimated that from 10 to 1000 yards of cotton cloth are used in each of these courses in the form of awnings, pennants, umbrellas. This also suggests a hazard in combination with smoking. Cuspidors are frequently found in indoor courses and these should not be filled with sawdust.

Interference with fire apparatus due to parking of cars around such courses may become rather serious in certain places where there are narrow streets and where the courses are located in congested districts. There is also a possibility of a nuisance hazard, due to these courses being run late at night and causing undesirable noise in residential districts.

The town planner is confronted with the question of where these courses can be allowed under a zoning law. Most zoning acts cover both buildings and premises, but a few of the older ones, especially in Massachusetts, cover buildings only. In this case the zoning ordinance should be amended to cover an addition, "structures and premises." Miniature golf courses are in general excluded from the residential districts by zoning ordinances because they are run as a business, and business is prohibited in these zones.

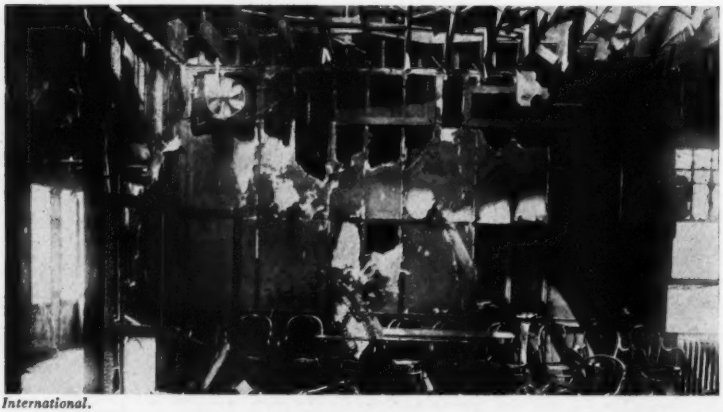
Federal Trade Commission Fire, Washington.

A fire, which seriously threatened complete destruction of valuable records and statistics, destroyed the two-story "temporary" structure housing the Federal Trade Commission in Washington, D. C., on the afternoon of August 30, 1930.

The building involved in the fire was erected in 1917 by the U. S. Government as a temporary office building. It was a two-story, part basement, structure of frame construction with interior walls and ceilings of plaster board. The beams and joists were thus sealed up. The exterior walls were stucco finish. The ground area was approximately 230 x 400 feet, with five interior wings or six courts. The building was occupied throughout by the

International.

Federal Trade Commission Fire, Washington, D. C. The roof and part of the second floor were badly damaged. Fire fighting at close range was handicapped due to the inferior construction of the building.



International.

The conference room of the Federal Trade Commission building after the fire. The interior walls and ceilings were of plaster board throughout. Flimsy construction made a hot, quick fire.

Federal Trade Commission, the Women's Bureau, Department of Labor, and the Children's Bureau.

The fire originated in a storeroom for office supplies and the first floor, at the north end of the fifth wing. It spread to the corridor, up the main stairway to the corridor on the second floor, and thence to the attic and roof. The greater portion of the roof and second floor of the interior wings were practically destroyed by fire, and the contents of the first floor were badly damaged by smoke and water.

The cause of the fire has not been definitely ascertained, and the Fire Marshal of the District of Columbia reports that it was probably due to careless smoking. While no actual figures are yet available, the losses have been estimated to be about $175,000 to the building and $25,000 to contents.

In the light of other fires within the past year in government buildings, this fire brought forth many editorials from the press of the country. Of these, one of the best is that appearing in *Engineering News-Record* for October 2, 1930, which is as follows:

Governmental Neglect.

While undertaking reform of the private house-building field the national government might also devote some attention to reforming its own building practice. It has allowed unsafe, inadequate, improvised buildings to continue in service for a dozen years, as sole accommodation of important governmental bureaus and departments in Washington, without attempting either to replace them by new and proper structures or to render them reasonably safe by installing protective devices. A fire in the Federal Trade Commission building at Washington a month ago brought these conditions to notice most glaringly, but they have been known for years. During the war, many one- and two-story buildings of wood frame construction were erected in Washington to provide increased space for the enlarged gov-

ernmental staffs. Work was in such a hurry and the buildings were intended to be so temporary in their occupancy that no automatic sprinklers were put in, and nothing beyond occasional hose lines furnishes protection against fire. Now, a dozen years later, something over a million and a half square feet of floor space of these unsafe temporary buildings remain, and still are in use, still without replacement and still lacking even sprinkler protection. Other temporary buildings, which are duly sprinklered or are more substantially built, are not included in this count. Government officials have preached to the country the duty of safe construction and safe maintenance of plant, but they themselves do not follow their own preachment. Perhaps a modest amount of good example would be worth a large amount of exhortation. Should there be another fire like that in the Federal Trade Commission and should it happen during working hours instead of at a time when the building is empty, the situation is likely to have further and rather sensational emphasis.

Keystone.

While firemen fought the flames in the attic and on the roof, employees and volunteers removed valuable records from the first floor offices of the Federal Trade Commission.

Fireworks in New Jersey.

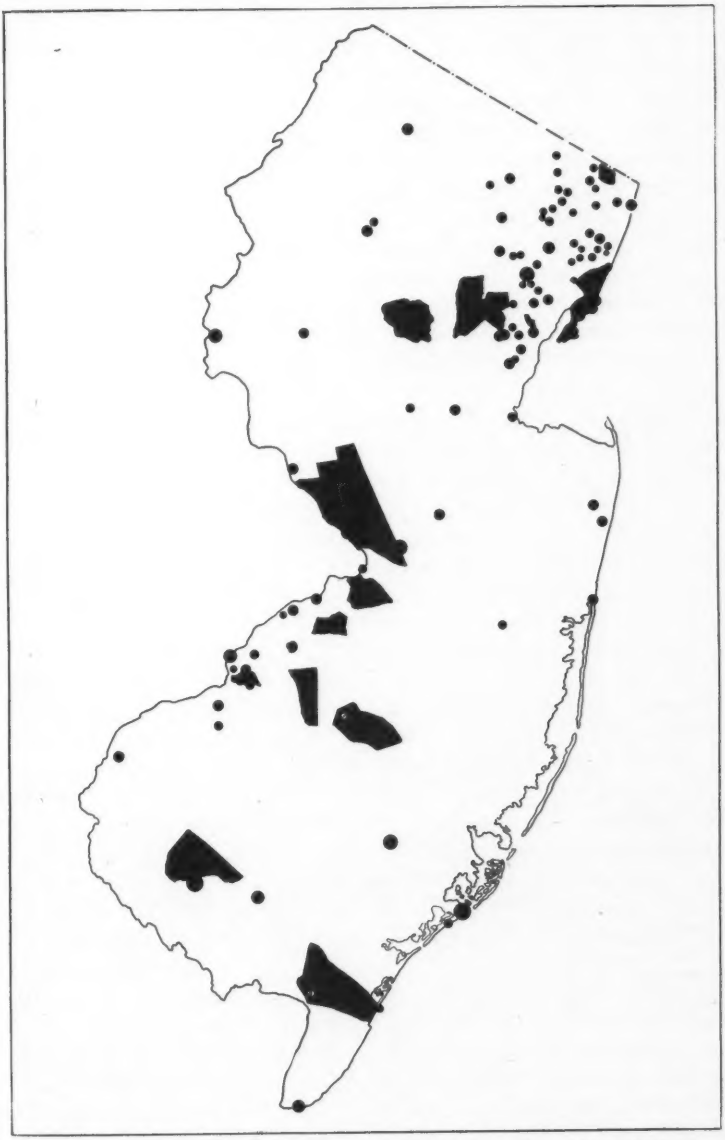
Fireworks legislation in New Jersey and its results in the celebration of Independence Day, 1930, have been surveyed by the Bureau of Explosives of the New Jersey State Department of Labor, which has jurisdiction over the enforcement of the State law and regulations on this subject. This comprehensive State-wide survey, the first detailed compilation of this character which has come to the N.F.P.A. Executive Office, is of interest not only in giving a clear picture of the present situation in New Jersey, but is more or less typical of the situation in other states which are confronted with the fireworks hazard.

Fireworks ordinances of the general character recommended by the N.F.P.A. are now in force in more than 100 individual communities of New Jersey. These ordinances prohibit the public sale of fireworks and recognize pyrotechnic displays only in public exhibitions under competent supervision. Legislation of this type is the only way effectively to keep fireworks out of the hands of children and others unable to use them safely, and is generally recommended by all fire protection authorities.

In addition to the New Jersey communities definitely prohibiting fireworks, there are a score which restrict the sale of fireworks in respect to the details of time of sale and use, size of firecrackers, etc. These ordinances, while not fully satisfactory from the fire protection viewpoint, do much to mitigate the hazard in the communities where they are enforced.

The accompanying map shows the distribution of the cities and townships with such ordinances in effect. It will be noted that these communities are well distributed throughout the state and that most of the larger cities and many townships have ordinances. The map also shows, however, that fireworks ordinances cover only a small fraction of the total area of the state. Everywhere outside of the prohibited area fireworks may be freely sold to the general public. It is a simple matter under present conditions for anyone desiring to purchase fireworks to obtain them outside of the prohibited area and bring them back for use at home. Such bootlegging of fireworks serves largely to nullify the effectiveness of the local ordinances. It is possible through efficient police supervision to curtail this bootlegging, but it is so widespread that as a practical matter it cannot be stopped.

The city of Trenton is an example of a community surrounded by territory where the unrestricted sale of fireworks is permitted, both in the near-by communities in New Jersey and in adjoining territory in Pennsylvania. The police authorities in the city of Trenton made a special effort to enforce the fireworks ordinances and achieved marked success, but despite their vigilance



Map of New Jersey, showing communities which have fireworks ordinances.

six accidents were reported from the city of Trenton during the Fourth of July period.

The following tables list the communities reporting Fourth of July accidents and fires:

List of Communities Reporting Fourth of July Accidents.

Jersey City	116	North Bergen Township	2
Newark	89	Rutherford	2
Camden	65	Seaside Park	2
Bayonne	49	Summit	2
Elizabeth	31	Union Beach	2
Paterson	20	Burlington	1
Pennsauken Township	10	Dover	1
Neptune Township	8	East Amwell Township	1
Rockaway	6	East Paterson	1
Trenton	6	Edgewater	1
Red Bank	5	Egg Harbor City	1
Wallington	5	Fieldsboro	1
Woodbury	5	Garfield	1
Carlstadt	5	Glen Gardner	1
Palmyra	4	Greenwich Twp. (Glouc. Co.)	1
Union City	4	Hamburg	1
Belleville	3	Kearny	1
Hoboken	3	Linden	1
Irvington	3	Little Egg Harbor Twp.	1
Oaklyn	3	Margate City	1
Passaic	3	Millstone	1
Somerville	3	Northfield	1
Atlantic City	2	Perth Amboy	1
Cape May Point	2	Pitman	1
Clementon	2	Sussex	1
Clifton	2	Vineland	1
East Rutherford	2	Washington Twp. (Bergen Co.)	1
Glassboro	2	Westwood	1
Lincoln Park	2	Woodbridge Township	1
Lodi	2		
Lyndhurst Township	2	Total	498

List of Communities Reporting Fourth of July Fires.

Newark	7	Bayonne	1
Carlstadt	3	Dumont	1
Asbury Park	2	Eatontown	1
Hoboken	2	Neptune Township	1
Irvington	2	Rahway	1
Jersey City	2	Riverton	1
Plainfield	2	Totowa	1
Seaside Park	2	Verona	1
Union City	2	Total	32

The majority of the accidents occurred in the cities which have ordinances. Jersey City and Newark, which head the list, both have fireworks ordinances, and in both the local authorities endeavored to enforce them. The fires and accidents reported were due to the purchase of fireworks outside the city limits, according to the New Jersey State Department of Labor.

It will thus be seen that local fireworks ordinances, while of undoubted value, are of limited effectiveness in reducing the fires and the accidents. It is only through state-wide legislation properly enforced that this hazard can be properly controlled.

The Regulation of Fireworks Manufacture.

The State of New Jersey is an important center for the manufacture of fireworks, the Bureau of Explosives of the State Department of Labor listing twenty-three fireworks plants operating within the state. Numerous accidents and fires have occurred in these plants, largely as a result of which the Haines Fireworks Regulations Act was made a law on March 25, 1930. This Act provides for the conduct of manufacturing operations under conditions which will minimize the hazard to surrounding property, to employees, and to the general public. Inspection and general supervision by the Bureau of Explosives is specified, and a permit for the operation of fireworks manufacturing plants requires the filing of a bond of ten to twenty thousand dollars to ensure proper compensation for any damage or injuries due to fire or explosion in the plant.

The same law also restricts the types of fireworks which may be manufactured, transported and sold within the state, prohibiting altogether the manufacture and distribution of the types which are considered particularly dangerous.

The most recent accident in connection with fireworks plants in New Jersey occurred on the property of the International Fireworks Company of Fairview on Friday morning, July 17th, when a building that had been discontinued by this company, but was being used for the storing of left-over Fourth of July fireworks, caught fire. The fireworks in the building were set off, causing the building to collapse and burning one woman, who was testing some of the old fireworks, so severely that she died shortly afterwards. This slight explosion and fire caused absolutely no damage to any other building, and the only injury was that to the woman, who was in the building unknown to anyone at the plant.

However, such occurrences have been few since the Haines Fireworks Regulations Act became a law on March 25, 1930. The Bureau of Explosives of the Department of Labor has been very active in endeavoring to enforce this law and to eliminate the many hazards in connection with the manufacture, transportation, sale and display of fireworks. The factory inspectors of the department visited many stores and stands where fireworks were sold and ordered the sale discontinued of different kinds of fireworks, prohibited by

this law, which were classed as dangerous and were not to be manufactured or sold in the State of New Jersey under any circumstances. Special investigations have been conducted by the Bureau of places that were suspicious and reported to the department as handling fireworks illegally. Buildings have been investigated when reports were received that fireworks were being stored therein. Inspections were made of all the fireworks plants in New Jersey and any violations of the regulations were immediately taken care of.

The manufacture of fireworks as a rule is carried on by very careless persons. Investigations have indicated that smoking is carried on while manufacturing fireworks. In one case a pipe was found beside a man who was working on fireworks. In another case matches were found beside manufactured fireworks. On another occasion, in a plant where fireworks were being prepared for shipment, a partially burned cigarette was found. In connection with the display of fireworks by the manufacturers who made them, one of the owners of a plant was found deliberately smoking while setting up set pieces for display purposes. Great credit is due the Department of Labor for its thorough and competent inspection work.

Sea Isle Tots Become Human Fire Engines

The most unique piece of fire-fighting in the history of Sea Isle City, N. J., has just been made public by Cornelius Travis, a merchant, who quietly watched seven boys and girls extinguish a smoldering fire on the Boardwalk near his shop recently.

Observing the children making numerous trips from a near-by drinking fountain to a certain spot on the wooden way, he finally discovered what they were doing. A carelessly thrown cigarette had ignited a board in the walk, and the children were rushing to the fountain getting their mouths full of water and hurrying back to the spot to sprinkle it. They finally succeeded in accomplishing their purpose.

Paint and Lacquer Spraying—Fire Record.

According to Mr. G. B. Heckel, Secretary of the American Paint and Varnish Manufacturers Association, patents relating to spray painting were recorded as early as 1869, but the practical utilization of this finishing method did not begin until the late eighties or early nineties. The buildings of the World's Columbian Exposition at Chicago in 1893 were coated in this way. Shortly after 1890 the artist's small air brush appeared and at about this time the spray application of lacquer and paint to manufactured articles of brass, bronze and wrought iron was successfully accomplished.

From these simple beginnings a great industry has developed, its economy in labor saving and uniform character of finish secured being largely responsible for the rapid expansion of its use. In the automobile finishing field alone the use of the spray method of finishing has made possible the amazing production with which everyone is familiar. The spray gun has also made practicable the use of pyroxylin lacquers in this and other industries, which still further facilitate speed of production. In the finishing of furniture also this method has been almost universally adopted for the same reasons that have led to its use in the automobile industry.

Up to 1925 spray finishing was mainly confined to relatively small objects, and while its use was general it was not until the year mentioned that the large scale use of spray finishing appeared in major industries.

During the period 1925-1927 there occurred a series of fires involving some loss of life and extensive monetary losses; these were attributed to the use of flammable finishing materials and served to focus the attention of various regulatory bodies. There was considerable feeling that these fires were caused by the use of pyroxylin lacquers, but investigation including a study of the properties of the various finishing materials involved clearly indicated the inherent hazards of the spraying process as the primary cause, and construction weaknesses from the standpoint of fire prevention and protection in the buildings housing the process as a contributing factor. The fire insurance interests became concerned as to the hazard introduced by this method of finishing, and the feeling in general was that drastic regulations should be drawn without delay in order to safeguard the hazard. There were in existence prior to this time published regulations for the safeguarding of spraying operations, but these were drawn around small scale intermittent operations and therefore not

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This analysis has been prepared by the Special N.F.P.A. Committee, H. E. Newell, chairman, W. D. Milne, H. L. Miner, Benjamin Richards, A. H. Nuckolls, N. J. Thompson, as a supplement to the brochure, "The Spray Application of Flammable Finishing Materials," published in the QUARTERLY in April, 1928 (Vol. 21, No. 4, p. 350). The brochure has been reprinted in pamphlet form and is available from the N.F.P.A. Executive Office on request.

adequate for the scale of production operations such as practiced in the automobile and furniture industries. The task of preparing the necessary requirements was accordingly assigned to the Committee on Manufacturing Risks and Special Hazards of the National Fire Protection Association. This work was speedily completed through the hearty coöperation of the paint and lacquer manufacturers, the manufacturers of spraying equipment and the insurance interests. The completed regulations were adopted by the National Board of Fire Underwriters, and their enforcement by the fire insurance interests is primarily responsible for the effective control thereby obtained. This enforcement was facilitated to a marked degree by a brochure dealing with the spray application of flammable finishing materials issued by the National Fire Protection Association.* More than 40,000 copies of the brochure were distributed through various channels, and without doubt this resulted in enlightening users of the spraying process as to the hazards involved and the necessary safeguards.

Because of the rapid growth of this process it is of pronounced interest to study its fire record from the start of its large scale application and note the influence thereon of the control brought about through the observance of proper safeguards, as previously described.

The following record of fires involving the spray application of flammable finishing materials has been compiled from the fires recorded in the files of the National Fire Protection Association Department of Fire Record between January 1, 1925, and January 1, 1930. The compilation has entailed a review of between fifteen and twenty thousand fires which have been classified during the five-year period. This fire record is limited to an analysis of the one hundred and ninety-four (194) fires involving the spraying process which have occurred during this period. Although these 194 fires are by no means all the fires which have occurred during this period involving the spray application of flammable finishing materials, it is reasonable to assume that they represent a cross section of the total fire record of this class and that the results and conclusions resulting from the analysis of these 194 fires apply equally to the record as a whole.

Of the 116 fires involving the spraying of lacquer during this period, 21, or 18 per cent, occurred in 1925; 37, or 32 per cent, in 1926; 25, or 21 per cent, in 1927; 20, or 18 per cent, in 1928; and 13, or 11 per cent, in 1929. This record is graphically illustrated by the following chart, which also shows the steadily decreasing number of fires following the adoption and enforcement of the revised regulations in 1926.

During this five-year period the production of pyroxylin lacquers was quadrupled. This is largely accounted for by the corresponding increase in popularity of the spray method of application. On the other hand, the chart

*See footnote at the beginning of this article.

shows that despite this great increase in production, or expressed otherwise, despite the greatly increased use of the spray method of application, the number of fires after 1926 decreased rapidly, the rate of decrease greatly exceeding the rate of increase in production.

During the five-year period the manufacture of paints and varnishes increased 10 per cent.

Table 1. Process Involved.

Process Involved	1925	1926	1927	1928	1929	Total
Lacquer spraying	21	37	25	20	13	116
Paint spraying	14	16	8	5	5	48
Paint	8	9	5	2	3	27
Enamel	2	2	1	1	2	8
Varnish	4	3	0	2	0	9
Shellac	0	1	1	0	0	2
Japan	0	1	1	0	0	2
Lacquer and paint spraying	4	6	6	3	5	24
Data incomplete	0	2	0	2	2	6
Total	39	61	39	30	25	194

Table 2. Point of Origin of Fire.

	Lacquer Spraying		Paint Spraying		Lacquer and Paint	No Data	Total No.
	No. Fires	%	No. Fires	%	No. Fires	No. Fires	Fires
Fire occurred in spray booth, hood, tunnel or vent ducts thereto	88	76	40	84	20	4	152
Fire occurred outside of booth, but spread thereto	10	9	5	10	0	0	15
Fire occurred in spray room. No data as to spread to booth	18	15	3	6	4	2	27
Total	116	100	48	100	24	6	194

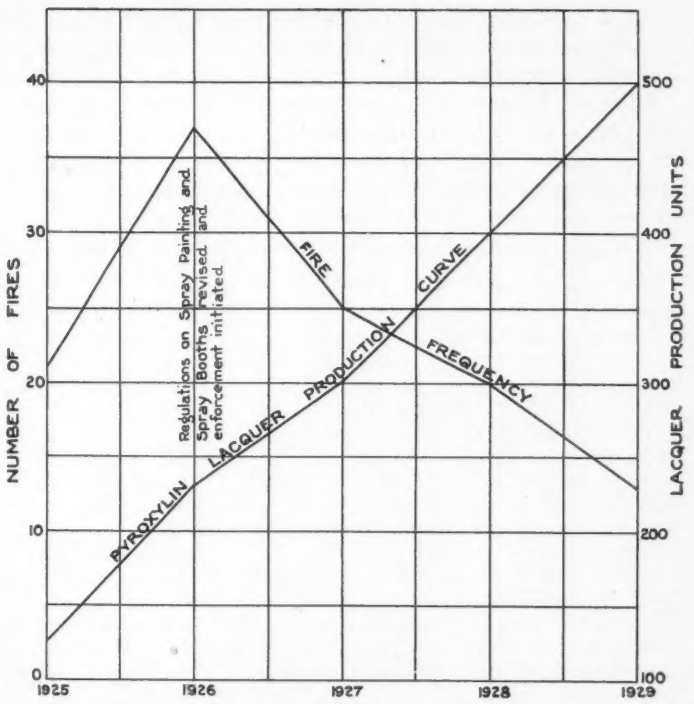
Table 3. Processes by Occupancy.

Occupancy	Lacquer Spraying	Paint Spraying	Lacquer and Paint Spray	No Data	Total
Automobile mfg.	18	6	0	0	24
Automobile body mfg.	13	4	2	0	19
Automobile paint shops	4	0	1	0	5
Car mfg. plants	0	1	0	0	1
Casket factories	3	0	1	0	4
Electrical appliance mfg.	22	1	2	2	27
Furniture mfg.	18	21	11	4	54
Leather mfg.	2	0	0	0	2
Light metal workers	21	5	2	0	28
Metal bed and spring mfg.	0	4	2	0	6
Radio equipment mfg.	3	0	1	0	4
Stove mfg.	0	0	1	0	1
Woodworkers—miscellaneous	5	3	0	0	8
Miscellaneous mfg.	7	3	1	0	11
Total	116	48	24	6	194

An analysis of Table 3 indicates that the greater number of fires occur in occupancies where continuous spraying operations are carried on, as in the case of the automobile, furniture and electrical appliance industries.

TABLE OF CAUSES OF FIRES IN CONNECTION WITH THE SPRAY APPLICATION OF INFLAMMABLE FINISHES

CAUSE	LACQUER SPRAYING				PAINT SPRAYING				LACQUER AND/OR PAINT SPRAYING				TOTAL			
	IN SPRAY BOOTH	SPREAD TO BOOTH	IN SPRAY ROOM	TOTAL	IN SPRAY BOOTH	SPREAD TO BOOTH	IN SPRAY BOOTH	TOTAL	IN SPRAY BOOTH	SPREAD TO BOOTH	IN SPRAY ROOM	TOTAL	IN SPRAY BOOTH	SPREAD TO BOOTH	IN SPRAY ROOM	TOTAL
ELECTRICAL CAUSES																
Spark or Short Circuit at Fan Motor	10			10	2			2	2			2	14			14
Spark from broken light bulb ignited residue or vapor.	8			8	4			4	1		1	2	13		1	14
Spark from short circuit, defective connections, motors or switches	14	2	3	19	8	1	1	10	7		2	9	29	3	6	38
Spark from open electric socket ignited gasoline used to clean booth.					3			3					3			3
Spark from switch ignited gasoline used to clean spray gun.																
Other electrical causes.	2		1	3									2		1	3
CARELESS OPERATION AND MAINTENANCE.																
Metallic Spark ignited residue while making repairs	2			2									2			2
Blow torch used for repairs or cleaning ignited residue	2			2	1			1					3			3
Sparks from friction due to Scraping booth while cleaning	3			3	2			2	2			2	7			7
Smoking - matches	8	2		10	2			2					10	2		12
Oily rags on steam radiator ignited		1		1		2		2						3		3
Sparks from acetylene torch ignited residue.		1		1		1		1						2		2
Vapor ignited from open flame			3	3							1	1			4	4
Sundry causes due to careless operation or maintenance	2		4	6			1	1					2		5	7
SPONTANEOUS IGNITION																
Residue and/or dust	12		2	14	12			12	7			7	31		2	33
Oily rags and waste	2		2	4	4			4	1			1	7		2	9
MISCELLANEOUS																
Hot fan bearing ignited vapor	2			2									2			2
Static Spark	2		2	4			1	1					2		3	5
Metallic spark from fan blade	2			2					1		1	2	3		1	4
Spark from fuel oil furnace ignited residue					1			1					1			
Spark from bonfire ignited residue and flashed back thru vent duct		2		2										2		2
Fire in adjacent room drawn into vent duct and booth by fan.		1		1										1		1
UNDETERMINED	17	1	1	18	1	1		2	3		1	4	21	2	2	25
TOTAL	88	10	18	116	40	5	3	48	24		6	30	152	15	27	193



A study of the table of fire causes (Table 4) develops some interesting facts. Of the 116 fires involving lacquer spraying solely, 22.2 per cent were due to electrical causes; 39 per cent careless operation and maintenance; and 22.2 per cent spontaneous ignition. The remaining 16.6 per cent were due to miscellaneous or undetermined causes.

Of the 194 fires, comprising the total number involving lacquers and paints in general, 37.2 per cent were due to electrical causes; 20.6 per cent careless operation and maintenance, and 21.6 per cent spontaneous ignition (bad housekeeping). The remaining 20.6 per cent were due to miscellaneous or undetermined causes.

Thus this record indicates three principal causes for fires involving spraying operations, *i.e.*, electrical causes, careless operation and maintenance, and spontaneous ignition. In the case of lacquer spraying solely, these three were responsible for 83.4 per cent of the fires, and for 79.4 per cent of the total number of fires involving paint and lacquer spraying in general.

It is also of interest to note that for lacquer spraying solely, 76 per cent of the fires originated in the booth, while for spraying operations in general this figure is 75 per cent.

Table 5 emphasizes the value of automatic sprinklers and hose streams for the extinguishment of fires involving the spraying process. Sprinklers alone were responsible for the extinguishment of 21 per cent of the total number of fires, and in combination with hose streams, for 42 per cent of this total number. Automatic sprinklers alone and in combination with hose streams, chemical extinguishers, sand and water pails figure in the extinguishment of 84 per cent of the fires. Chemical extinguishers alone and in combination with hose streams were employed in the extinguishment of 10 per cent of the fires, and hose streams solely for 6 per cent of the total number of fires.

Table 5. Method of Extinguishment.

Automatic sprinklers	41
Automatic sprinklers and chemical extinguishers	39
Automatic sprinklers and foam extinguishers	6
Automatic sprinklers and hose streams	41
Automatic sprinklers chemical extinguishers and hose streams	23
Automatic sprinklers foam extinguishers and hose streams	3
Automatic sprinklers, sand and hose streams	2
Automatic sprinklers and water pails	2
Automatic sprinklers, water pails and chemical extinguishers	2
Automatic sprinklers, foam and chemical extinguishers	2
Automatic sprinklers, water pails and sand	1
Automatic sprinklers, foam and chemical extinguishers and hose streams	1
Chemical extinguishers	8
Chemical extinguishers and hose streams	3
Chemical and foam extinguishers	1
Chemical and foam extinguishers and hose streams	1
Hose streams	11
Hose streams and foam	1
No data	6
Total	194

Extent of Losses.

Definite loss figures are available for only 166 of the total number of fires; these are shown by the following table:

Table 6. Losses.

	Number	Per Cent
$1,000 or less	104	62.6
$1,001 to $10,000	34	20.0
$10,001 to $25,000	11	7.0
$25,001 to $50,000	5	3.2
$50,001 to $100,000	5	3.2
Over $100,000	7	4.0
Total	166	100.0

Of the remaining 28 fires, the losses in 10 cases are classified as "moderate," in 6 cases as considerable, and in 11, large. In one case the loss was not indicated.

Conclusions.

It is apparent from the fire record that effective control of the hazard inherent to the spray application of flammable finishing materials has been secured through the enforcement of suitable regulations governing spray painting and spray booths, and the dissemination of informative matter concerning these hazards and the measures necessary for safeguarding them. Thus a process of pronounced economic value has been permitted to extend to every field of possible application through intelligently planned and applied regulations, a most striking example of the value to industry of proper regulations.

On the other hand, the number of fires that have occurred were apparently due to preventable causes, a fact readily obvious by even casual study of the table of fire causes. This table is of decided interest to those charged with the preventing of fires where flammable finishing materials are applied by the spray method, in that it emphasizes the fire causes most common and indicates the features or conditions which create a greater degree of hazard when not properly safeguarded or supervised.

Radios.

By Lori Petri.

The lives of men are much like radios . . .
A cosmic station, which God operates,
Broadcasts, thru time and space, a force that flows
Afar in subtle waves, and concentrates
In pools of personal identity.
And then, turned on by the strange switch of birth,
These vivid, pulsing points of entity
Pour forth their programs to the listening earth.
Their rhythms preach and screech and sob and dance.
They send out symphonies and sallies, till,
With one quick flip, the hand of circumstance
Shuts off the power and leaves them cold and still.

Failure of San Francisco Salt Water Main.

Fireman's Fund Record.

A flood accompanied by fire and general havoc followed the bursting of a 16-inch salt water main of the Olympic Salt Water Pumping Company, on the Anza-Balboa block of Forty-seventh Avenue, in San Francisco, California, on the 18th of March, 1930.

The bursting of the main occurred at 5:30 P.M., releasing an avalanche of water, which swept down the grade of Forty-seventh Avenue. For the length of an entire block the street was caved in, carrying with it a delivery truck. Other automobiles were swept along by the rush of water or were buried to their radiator caps in mud and silt. A Postal Telegraph trans-Pacific cable line was snapped, electric light service in the district was crippled, and broken gas pipes flooded the area with their deadly fumes.

In the midst of the confusion thus occasioned, a house caught fire when the occupant, smelling gas from a broken pipe, tried to locate the leak in the usual way—with a lighted match or candle. Firemen, three of whom were injured, fought desperately to save the burning structure, but the lack of water and the chasm which suddenly had replaced the pavement of the street seriously handicapped their efforts. The dwelling was considerably damaged and the wall and roof of an adjoining dwelling somewhat scorched.

Fireman's Fund Record.

San Francisco street caved in by bursting water main. Note truck at bottom of chasm thus formed.

The pipe which caused all the damage is the property of a private water company which supplies salt water to a number of bath houses in the city and furnishes public fire protection from thirty-two hydrants. The system of mains of this company consists of a 16-inch line from the pumping station to a reservoir, with distribution mains of 14-inch, 12-inch, 6-inch and 4-inch pipe. Most of the hydrants are supplied directly from the 16-inch main The mains are cast iron, have nearly all been in service for over 30 years, and are said to be badly tuberculated and incrusted.

A leak had started and gradually washed away the sand from beneath the pipe. When the pipe had been undermined for a sufficient length it probably snapped of its own weight, and the volume of water under approximately seventy-five pounds pressure caved in the street. Other pipes beneath the surface of the street were undermined and their own weight caused them to break.

The street damage alone was estimated at $30,000, and the loss to the dwellings, damaged by fire, was approximately $5,000.

Fireman's Fund Record.

Looking down grade on Forty-seventh Street, San Francisco, showing damage done by bursting main. Home at the left caught fire and was destroyed, due to lack of water for fire fighting.

Locating Leaks in Underground Yard Mains.

To determine if there is any abnormal leakage in a private fire system, it is first important to make sure by a careful check-up that no water is being used for mill-use purposes. Such connections preferably should be eliminated.

Allowance must also be made for the slight leakage which usually occurs at lead joints of underground pipes. Any amount less than about 1½ gallons per day per linear foot of lead joint is not considered excessive. The amount of such leakage can be roughly calculated from the following table, which applies to private yard systems usually having a relatively large proportion of short lengths, fittings, valves, and hydrants.

Determining Rate of Leakage.

Size of Pipe	Linear Feet of Lead Joint per Running Foot of Pipe
12-inch	0.39
10-inch	0.29
8-inch	0.23
6-inch	0.22
4-inch	0.15

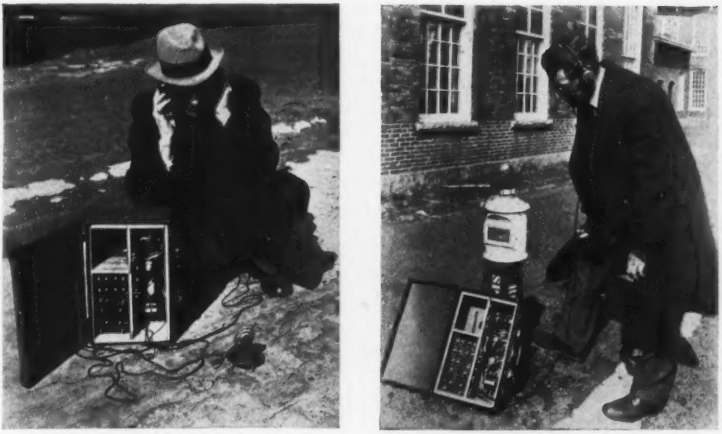
The next step is to determine the actual rate of leakage and to see if it greatly exceeds the normal permissible leakage as outlined above.

If the system is supplied through a metered connection from city mains, observations of ten to fifteen minutes' duration should be taken at frequent intervals, both when the plant is running and idle, noting whether the flow is regular or intermittent. An intermittent flow is almost always an indication of a mill-use connection not previously located. If the city connection is unmetered, a small meter can usually be borrowed from the public water department and installed on a by-pass around a valve on the city connection, using either small temporary piping or a hose line from a street hydrant to one in the yard, with readings taken with this city valve shut.

If the system is supplied by a gravity tank, the rate of leakage may be quite accurately determined by measuring the rate at which water level falls. Where the pressure in the city mains fluctuates and at times is nearly the same as the pressure from the tank, the clapper on the city check valve may float on its seat so that water will pass into the city mains. Such loss should not be mistaken for leakage from underground piping.

When neither a meter nor a tank is available, an Underwriter pump can often be utilized to measure the rate of leakage with a fair degree of accuracy. The "slip" of the pump should first be determined by closing the discharge valve and noting the speed necessary to maintain at the pump the same pres-

Reprinted from *Factory Mutual Record.*



Electric Leak-Locator. The microphone may be placed on the ground or on indicator posts or hydrants. A volume control used to eliminate foreign noises makes the device effective for quite small leaks.

sure which normally stands on the system. The valve should then be opened and the speed determined at which the pump maintains this pressure on the system. The leakage may be calculated from the difference in displacements corresponding to these two speeds.

A rougher approximation of the leakage may be obtained by another method. This is to close the main supply valves and then by gauge readings on any part of the system to note the loss in pressure over a period terminating when the dropping pressure begins to slow up. The amount of leakage for this period is obtained by refilling the system, again closing the supply valves, then quickly drawing off into large measuring containers enough water to lower the pressure the same amount.

Locating Leaks.

After determining the amount of leakage and finding it abnormal, the location may be determined in any of several ways. Various types of listening devices have been developed for locating leaks in underground piping, the simplest of which is a telephone receiver with a steel rod attached to the diaphragm. It is used by holding the end of the rod on indicator posts and hydrants, but is not effective for listening through the ground.

Another simple device is based upon the principle of the geophone, developed during the war to detect sapping and mining. It is quite sensitive and can be used either on hydrants and indicator posts or on the ground. (See cut.) Each of the two detecting units of the geophone consists of a lead weight attached between two thin metal diaphragms which are tightly clamped along their outer rims in a metal case. These units transform the vibrations

Two types of leak locators in quite general use by public water departments. The one at left is based on the principle of the geophone developed during the war. The one at right uses a microphone, electric circuit, and earphones.

in the ground caused by a leak into sound waves which are conducted through rubber tubes to earphones similar to a doctor's stethoscope.

Still another commercial device known as an "electric leak-locator" consists of a carbon-button microphone mounted on a metal table in series with an amplifying unit with a telephone head set for listening. It is subject to inherent electrical noises and to outside sounds, and therefore for best results must be used when the plant is idle and the noises of manufacturing processes are absent.

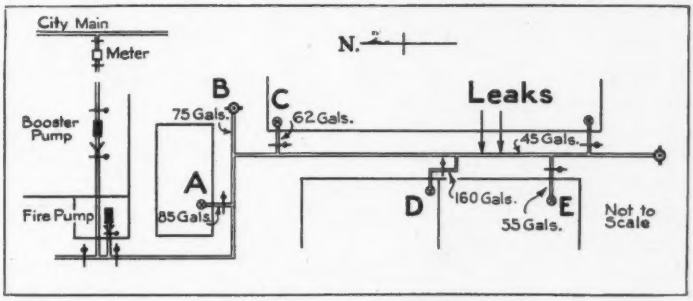
For their own use the Factory Mutual Laboratories have recently constructed an electric leak-locator which, like the commercial device, uses a microphone and head phones, but has radio tubes for amplification. Because this leak-locator is very sensitive, it has a volume control with which one can largely eliminate foreign noises by cutting down the input current. It has proved valuable in locating even quite small leaks.

The degree of successful use of these listening devices seems to vary with the experience of the operator. With any of the devices that can be used directly on the ground, most leaks can be located with sufficient accuracy. Leaks in underground pipe in swampy fill, or where there is surface water to diffuse the sound of escaping water, are difficult to locate with any of the above devices.

When it is impracticable to use a listening device, as in swampy ground or under a stream or yard storage pile, or when a check is desired, a leak may be located by introducing an alkali or dye into the system near the source of supply and then making observations to follow the flow of the alkaline or

colored water through the main to the leak. The velocity of this flow can be computed from the size of the pipe and the rate of leakage. Several convenient points, such as hydrants or riser drains, are chosen where the water can be drawn off and tested. (See sketch for detailed example.)

After sufficient time has elapsed for the water to reach the first draw-off point, if a test then shows the presence of alkali or dye, it indicates that the leak is at some point beyond. This procedure is repeated at successive draw-off points until no test for alkali or dye is obtained, indicating that the water is escaping through a leak at some point back toward the previous draw-off. Then the water should be drawn off and measured until a test is obtained. From the measured amount of water the distance along the pipe back to the leak can be computed and the leak located. Where there is but one leak in the vicinity, the location can be determined within a foot or two. At one plant a leak was located by the caustic method and, upon excavating, an old $1\frac{1}{4}$-inch valve connection to the yard main, the existence of which was unknown to the management, was found corroded off. This leak was located within a foot.



An Example of Leak Locating.

Meter readings indicated an abnormal leakage. A listening device showed a leak to be at a point marked by the northerly arrow. While excavating there the plant mechanics checked the location, using the caustic soda method as follows: Caustic soda was introduced into the yard main through a tapped connection at a point near the booster pump discharge line. The caustic would then be drawn through the piping system and out through the leak opening. Having previously determined the rate of leakage and knowing the size of the pipe, the men calculated the time required for the caustic to reach a point in the main line opposite A. At the proper time, through the riser drain at A, they drew off the calculated amount of water in the connection between the yard main and the drain, or 85 gallons. When more water was drawn, they obtained a test for caustic with phenolphthalein indicator showing that the leak was beyond this point. Similarly and in turn, it was determined that the leak was beyond the connections to B, C, and D. When the calculated amount of water in the connection opposite E was drawn, no test for caustic was obtained, showing the caustic was passing out of the yard main at some point between D and E. Additional water was drawn and measured until a phenolphthalein test indicated caustic. From the amount drawn a leak was determined to be located at a point indicated by the southerly arrow. When the pipe was uncovered, the lead joints at both ends of one length of pipe were found leaking and were recaulked.

At another mill a leak was located in a yard main running along an important railroad siding. In order to save time in completing repairs and restoring the siding to use, excavation was made simultaneously at three different points at 12-foot intervals. When the pipe was uncovered, the leak was found within one pipe length of where it was computed. Caustic soda is usually used with phenolphthalein as an indicator, showing red in the presence of the alkali.

Fuchsine, a strong but harmless coal-tar dye, may be used instead, and indicates by its own color. The dye has been successfully used in the marshy sections near Chicago, where the water from leaks would escape without sound enough to be detected by a listening device. At one plant where the dye was used, the leak was determined to be under the foundations of a building, and upon excavating was found three feet inside.

An abnormal loss of water from underground systems is a waste which should be eliminated, and it is hoped that this information may be helpful to our assured in locating any such leakage.

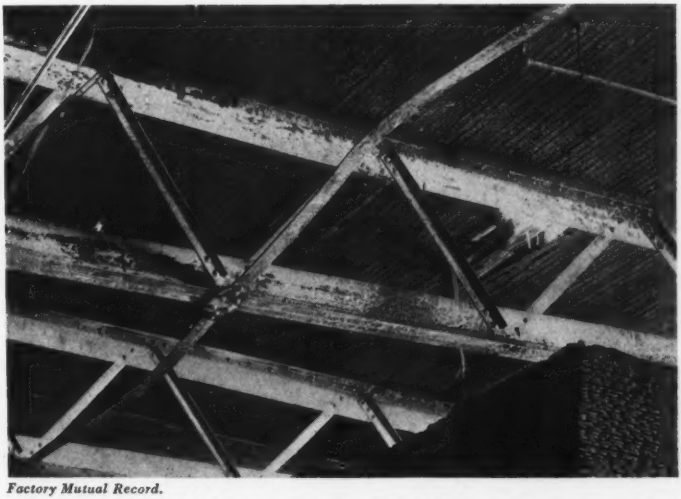
Sprinklers Shut Off.

A closed sprinkler valve, which delayed the normal operation of the automatic sprinklers, was a factor in a combined fire and use and occupancy loss of more than $40,000 in the plant of the International Fibre Board Company at Gatineau, P. Q., on July 20, 1930.

The fire started at 12:05 A.M. near the delivery end of a kiln used for drying wood fiber wallboard in the kiln building. It was caused by the spontaneous ignition of the wallboard. The fire quickly communicated to the piles of finished wallboard stored near by and ignited the under surface of the roof. Automatic sprinklers were provided in this section of the building, but had been shut off several days previous, following a small fire. As no extra heads were then available the valve had been permitted to remain closed. Thus the safety normally afforded by the sprinkler equipment was lost and the fire continued to spread throughout the northern half of the kiln building, aided by the dry and dusty condition of the structure.

Fortunately, the sprinklers in the remainder of the building were supplied by a different riser and had been maintained in normal condition. They kept the blaze from spreading throughout the entire structure. The kiln operator was on the job and opened the shut valve soon after the fire started. With 177 sprinklers operating and with ample water supply from the three 2500-gallon pumps available, the fire was promptly brought under control and extinguished.

However, had the delay in opening the closed valve been slightly longer the roof would have fallen and the loss consequently much greater. The steel trusses were actually at the point of collapse when the water was turned on the sprinklers, as shown by the partial deflection of certain members. The damage was confined mostly to the roof, kiln, wallboard and electric wiring. (S-52303.)



Factory Mutual Record.

No replacement sprinklers being available following a small fire, the valve was left closed. A few days later another fire swept through this section, charring the planking, warping the trusses, and damaging piles of wood-fiber wallboard (lower right) before the shut valve could be opened.

Plane Fire Extinguished with Carbon Dioxide.

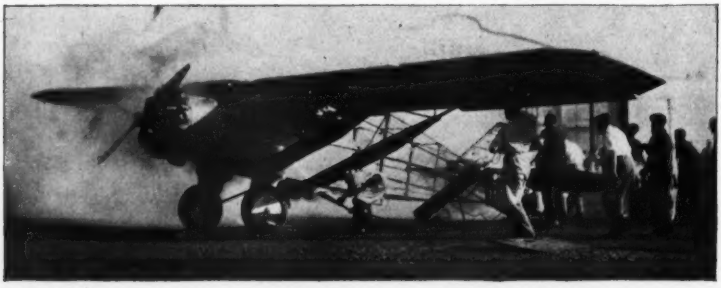
Carbon dioxide portable fire extinguishers promptly applied by the personnel of the Boston Airport on September 4, 1930, extinguished with a relatively small damage a serious fire in the Bellanca monoplane in which Russell Boardman had planned to cross the Atlantic Ocean and tour Europe. This case is of unusual interest because of the effective work done with carbon dioxide and other extinguishers under inherently unfavorable conditions. The plane was in the open, where wind or any slight breeze would tend to carry away the carbon dioxide gas and interfere with its smothering action.

Carbon tetrachloride and soda acid extinguishers also contributed to the control of this fire, supplementing the work of the carbon dioxide extinguishers, but to the latter belongs the primary credit for controlling the fire. Unusual efficiency was shown by the airport personnel in attacking the fire in its incipiency and practically extinguishing it even before the very prompt arrival of the Boston fire department.

Story of the Fire.

On the eve of his take-off in an attempt at the two-way crossing of the Atlantic, the airplane of Russell Boardman was slightly damaged by fire. The plane was a model CH Bellanca monoplane with a wing spread of fifty-two feet and a total length of twenty-five feet. It was equipped with a Wright J6 engine, and had six gasoline tanks as follows: two permanent tanks in each wing, one large tank in the fuselage and one auxiliary tank in the fuselage, with a total capacity of six hundred gallons of gasoline. The tanks contained approximately one hundred and sixty-five gallons of gasoline.

At the time the fire occurred it is said that the mechanic was measuring gasoline into the plane so that Boardman might know the exact amount used



International.

Using carbon dioxide on the Bellanca Monoplane fire, Boston Airport, September 4. Note men discharging nozzle under fuselage. The cabin was flooded with the gas, thus keeping fire from spreading to the power plant and preserving the valuable instruments from damage.

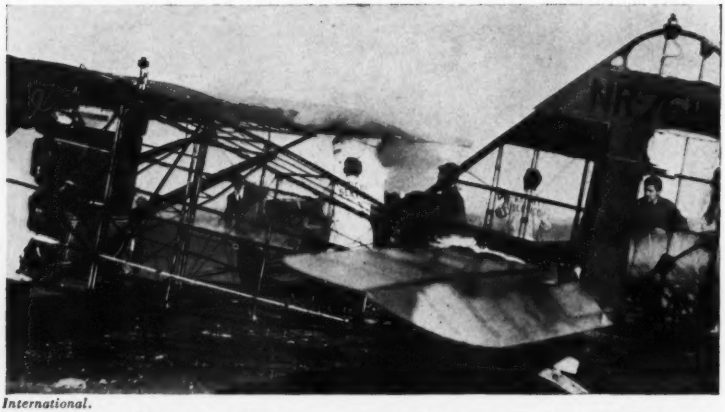
International.

Fire in the Bellanca Monoplane in which Russell Boardman planned to cross the Atlantic was promptly extinguished by the personnel of the Boston Airport on September 4, 1930. This picture shows some of the fire extinguishing equipment used. A number of wheeled carbon dioxide units were rushed from near-by hangars; soda acid and carbon tetrachloride devices were also used. While a considerable part of the wing fabric was destroyed, as shown by this picture, the power plant equipment was not affected, and it is estimated that the damage amounted to only fifteen per cent of the value of the plane.

in a test flight to New Bedford. A measuring can was used, which was being filled through hose from a gasoline pump and emptied into the tank. A small auxiliary tank had been fastened on top of the main tanks to be used for measuring purposes. This auxiliary tank was being filled from a can and funnel from the top of the center section, the gasoline placed in it being measured. It is apparent that either the funnel was not grounded to the auxiliary tank or that the can being used to fill the funnel was not grounded, since the mechanic performing this operation states that the flame flashed back from the gasoline tank as he was filling it. The flash-back set fire to the can of gasoline which the mechanic was holding and which he hesitated to throw away immediately on account of the surrounding crowd.

The cause of the fire is not definitely known, but it is thought to be due to static electricity generated by the potential set up either between the can and the funnel or between the funnel and the tank. This emphasizes the strict necessity of metallic grounding of all parts between which there is a flow of gasoline.

The flames raced along the fuselage of the plane toward the tail, enveloping the right wing and tail surface. Intense excitement prevailed, but the mechanic showed unusual courage and presence of mind. As the tank flashed, he pulled the gasoline hose, which was on fire, from the plane and jumped to the ground, after which he closed the hose in the metal covered pit housing the gasoline pumping equipment, thus preventing the possibility of igniting the pit. He was burned about the hands, but not seriously.



International.

Close-up of the fire, showing the wing fabric partially burned off, but the structure of the plane intact. Note the use of carbon dioxide extinguishers on the wing in the background of this picture.

The superintendent of the airport saw the fire from his office and sounded the airport fire alarm. Airport mechanics and attachés came running from all directions with fire extinguishers, and an alarm was sounded for the city fire department. The fire was fought with miscellaneous first aid equipment of the carbon dioxide, carbon tetrachloride and soda-acid types brought from near-by hangars. The carbon dioxide equipment consisted of two 100-lb., two 50-lb. wheeled type units and five hand extinguishers of the 7½ and 15-lb. sizes. The other equipment consisted of four or five 2½-gallon soda-acid extinguishers, and a few 1 qt. carbon tetrachloride extinguishers. The cockpit of the plane was filled with carbon dioxide, which smothered the fire in the interior and built up an inert atmosphere around the gas tanks to prevent any chance of explosion. The fire did not involve the gasoline tanks; after the fire their contents were found intact.

The fire was practically extinguished on the prompt arrival of the city fire department, making it unnecessary to use a line of hose. The good judgment and prompt and efficient handling of the fire by the personnel at the airport resulted in a small loss and no panic, although scores of people were attracted by the spectacular sight and employees not engaged in fire fighting were kept busy in driving bystanders back from the danger area in the event that tanks should explode. After the fire all extinguishers were promptly recharged and in service for a municipal air meet which started the next day.

The plane was valued in excess of $18,000, and the loss is estimated as under $2500. This represents a salvage of approximately 85%, a very unusual result in a fire of this character.

Hangar Fire Tests.

A series of tests to determine the practicability of controlling or extinguishing airplane hangar fires by automatic sprinklers was conducted last spring in Washington, D. C., by a Fact Finding Committee which had been organized by the Aeronautics Branch of the Department of Commerce to study this subject following differences of opinion between fire protection engineers and representatives of the aviation industry as to the value of automatic sprinkler protection in this occupancy. Motion pictures of the tests were shown at the 1930 annual meeting of the Association and a general description of the test program given. (Proceedings 1930, page 125.) At that time no official conclusions could be given as to these tests, as the committee had not completed its report. This report was completed during the past summer and is now in course of publication. The following summary has been extracted from the complete report and from an article thereon in the *Air Commerce Bulletin* of the U. S. Department of Commerce, which gives conclusive evidence as to the value of automatic sprinkler protection in hangars.

Program of Tests.

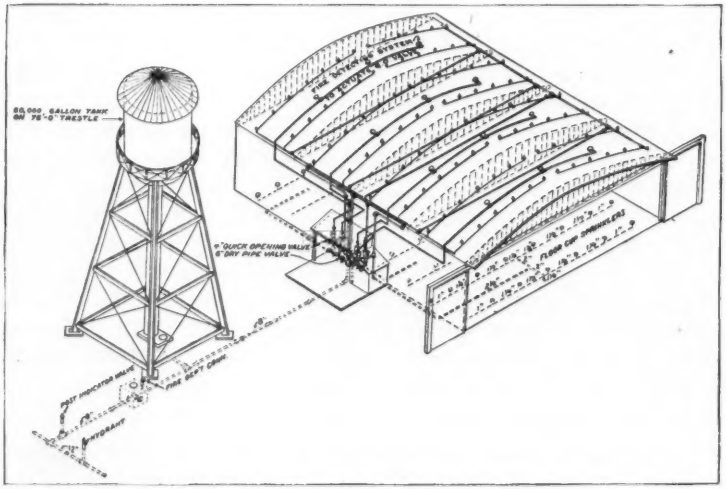
Consideration of the different sources or locations of ignition of fires in hangars determined that the test program should include (1) fire from a source exterior to the airplane causing ignition of a wing tip, (2) fire starting along and within the wing from a short circuit of the wiring system, (3) fire starting in leaking gasoline within the fuselage, and (4) fire starting in gasoline spilled on the floor and covering a large area. The start of fire is most uncertain and the variations are almost infinite, but it was thought that the divisions as given would represent the more usual conditions. The comparison of the different sprinkler systems, one with another, involved the repetition of the fires with all conditions duplicated. This was accomplished satisfactorily in most cases.

The objective of the committee was to make the tests as nearly conclusive as possible with respect to the effectiveness of control of airplane hangar fires by each of the four different systems of automatic sprinklers under the four conditions of fire and two conditions of plane storage; that is, for isolated or single planes and planes closely spaced in the hangar. It was also planned to make available to fire protection engineers the test data, both qualitative and quantitative, that would be useful in designing fire-protection systems for airplane hangars.

The complete report, now being printed, will shortly be available for distribution by the Aeronautics Branch of the Department of Commerce without charge upon request.

The Test Plant. Photograph taken after several fire tests. Tank at left furnished the secondary water supply. In the foreground may be seen planes to be used in further tests and the wreckage of burned planes.

The National Committee on Wood Utilization of the Department of Commerce, which is making a comprehensive study of airport structures, donated the hangar used for the tests. The hangar was of wood frame construction 66 feet 3 inches wide by 80 feet 8 inches long and 28 feet high with four traverse bowstring wood trusses spanning from wall to wall $18\frac{1}{2}$ feet above the floor. The studs, posts and other dimension timbers were of fir, and the wall and roof sheathing and drop siding were of yellow pine. The 2 by 6-inch wall studs and the 2 by 10-inch roof rafters were spaced 2 feet on



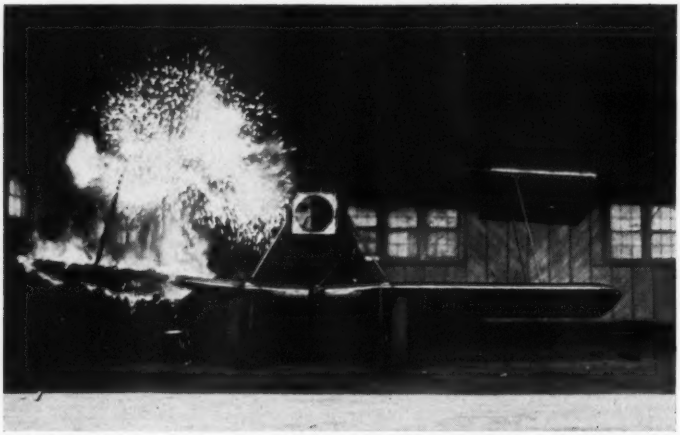
Isometric drawing showing the layout of the test plant.

Test No. 2. This picture was taken three and one-half minutes after the start of the fire against the wall; thirty seconds after the fire had spread from the wall to the wing of the plane.

centers. The sheathing, which was 1 by 6-inch square edge material, was nailed diagonally on the wall studs and square across the roof rafters. Waterproof sheathing paper was applied over the sheathing before the drop siding was nailed on. The roof was covered with a 55-pound granular surface ragfelt asphalt roll roofing. Two coats of aluminum bronze paint having a linseed oil base were sprayed on the interior of the hangar four or five weeks before the tests were started. The foundation wall, which was concrete, was continuous along the two sides and the rear of the building, and extended from 3 to 10 inches above the floor. The floor was of concrete, 4 inches thick, and was sloped to give drainage, which for the rear bay was through a trapped scupper at the side of the hangar, and for the other three bays through the doorway to a shallow trench across the front.

The arrangement of the airplanes within the hangar for the tests was sketched and the quantities of gasoline and oil for each noted. Records were made of the start and progress of the fires, of the temperatures under the roof, the time of action of the sprinkler system and also the rate of water flow and the quantities of water used for each test. Motion pictures of the tests were made by a photographer assigned by the Signal Corps of the United States Army and many still photographs by the Bureau of Standards photographer.

Four of the airplanes used in the tests had the fabric coverings finished with cellulose acetate dope, all others were finished with cellulose nitrate. The first test was made with the cellulose acetate doped fabric in its weathered



Test No. 6. A quick hot fire. This picture shows the characteristic burning of the wing fabric treated with nitro-cellulose "dope." The fireworks effect from the upper wing is due to aluminum bronze. This fire burned out so quickly that ordinary sprinklers did not open, although the automatic heat-actuated valve tripped.

condition, the others after giving the acetate doped fabric surfaces fresh coatings of acetate or nitrate dope or dope and gasoline to make the combustion rapid. Fresh coatings of nitrate dope were applied to some of the planes having fabrics coated with nitrate dope. These fresh coatings over nitrate dope were applied to offset the flame-retarding effect of aging and the salt water to which they had been subjected in service.

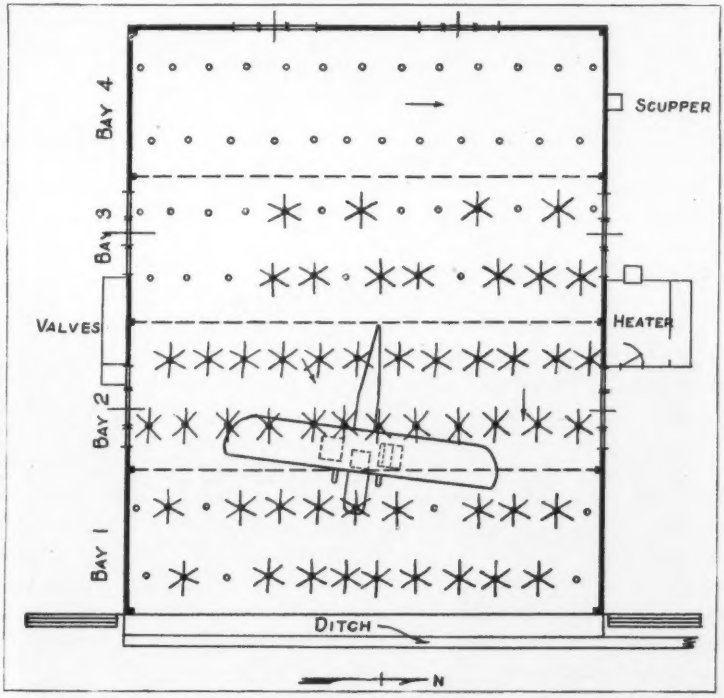
Test No. 10. This picture shows the operation of the floor sprinklers.

Gasoline was leaking from one or more tanks in several of the tests. This was purposely done in six of the tests to make the fires of near maximum severity for the kind of test involved. The effect of the leaks was to saturate the fabric and wet the surfaces exposed to the leaking fuel, causing a very rapid spread of fire and to continue the flaming after all other fire had been quenched by the sprinklers.

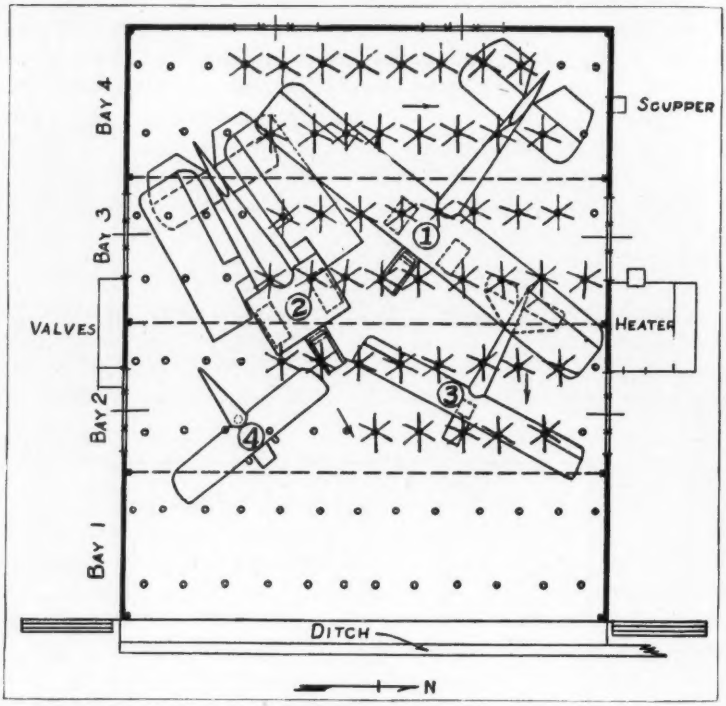
All of the tests were made with the hangar doors open. The primary purpose of this was to create the more unfavorable condition frequently found in practice. This arrangement also permitted closer observation and better recording of the tests.

Discussion and Conclusions.

It was realized beforehand that the number of tests that could be made would represent only a few of the possible conditions of origin and spread of fires in airplane hangars. The committee tried, however, to set up conditions for the tests such that reasonable interpretation could be made with respect



A fire of great intensity in Test No. 7 opened 53 sprinklers of the wet pipe system.



Forty-six sprinkler heads of the dry pipe system were opened in Test No. 8, confining the fire to airplane No. 1 in which it originated.

to other possible conditions which might be found in fires. For example, since the wooden hangar could not be reduced to the driest possible condition for each test, several of the tests were purposely made more severe than would be found under ordinary circumstances as an offset for the slightly less favorable condition for ignition of the building. These were more severe with respect to spread of fire from plane to plane than would be found normally. The more severe conditions with respect to the spread of fire and the open position of the doors may have militated against the best performance of the sprinkler equipment. The smallness of the room had its effect in both directions. The lower ceiling made it possible for the sprinklers to operate more quickly than they would where ceilings were higher and also the shortness of the pipe lines from the automatic control valves made possible quicker discharge of water at the open sprinklers. On the other hand, the low height permitted flames to sweep around or against the roof framing and boards, thus threatening their destruction. The small air capacity of the system and the relatively low air

pressure under which the dry-pipe valve was sealed also favored the system over conditions frequently found in practice with dry-pipe systems.

Conditions of water supply were favorable to the maintenance of good pressure at the sprinklers for the duration of the tests. That the water supply

Test No. 12. In this fire four planes were placed in the hangar with the 330 gallons of gasoline and 40 quarts of oil in the tanks and 15 gallons of gasoline spilled on the floor. This picture was taken ten seconds after the start of the fire.

Test No. 12. At thirty seconds after the start of the fire sprinklers had come into operation and further spread of the fire was checked.

Test No. 12. This picture was taken twenty seconds after the start of the fire. Compare this with the preceding illustration and note the extreme rapidity with which the fire has spread.

shall be reliable and furnish a sufficient amount for the maximum demand is as fundamental as the requirement that the sprinkler system shall be installed and maintained in accordance with recognized good practice.

The painting of the interior of the hangar with aluminum paint was of benefit in that it made ignition of the wood surfaces more difficult and far less affected by radiant heat, but at the same time it kept moisture from penetrating the exposed surfaces. The moisture content of the roof sheathing boards before the tests were begun was representative of extremely dry conditions; that of the side walls was what might usually be found in hangars in condition of use, normally air dry. The dry condition of the wood was largely the result of open fires which had been kept burning in the building by workmen for several weeks prior to the painting. The samples of wood taken from the inner surfaces of the sheathing from test to test indicated only small changes in the moisture content, particularly where it had been possible to have fire in the heater between tests.

The weather immediately before and during the tests was favorable. The temperature during the tests varied from 42° to 88° F., but was above 60° for all but three. The sun shone more than two-thirds of the time and breezes of from 3 to 10 miles per hour were usual. The low humidity of the atmosphere was also favorable, not only to the drying of the planes and building between tests, but to the rapid spread of fire and the ignition of surfaces exposed to flames. The relative humidity of the atmosphere varied from 33 to 50 per

cent for all but two tests and during these it was between 50 and 65 per cent. A few slight traces of rain occurred during the test period, but these were of very brief duration and never sufficient for measurement. The effects of these were soon dissipated by the wind and the low humidity prevailing.

The ventilation of the hangar was a compromise between the extremes of open windows, doors and roof ventilators, and complete closure of the building. The latter condition would have brought the sprinkler equipment into service much sooner than with the condition established for the tests; namely, with doors wide open and windows closed. Roof ventilators would have had the effect of drawing the flames and hot gases directly upward and thus would have been less favorable to the spread of fire from airplane to airplane, and since such ventilators when present are protected with sprinklers, there would be no serious increased hazard to a building so equipped.

The results of the tests and the observations with respect to the conditions surrounding them lead the committee to express the following conclusions as to the effectiveness of the automatic application of water by sprinklers in controlling airplane hangar fires:

(1) Slow-burning fires in well-ventilated buildings with high ceilings may continue without opening automatic sprinklers.

(2) Extremely fast fires in single planes may burn themselves out without opening automatic sprinklers.

(3) Fires in readily ignitable and highly combustible materials spread over wide areas, such as gasoline on the floor or highly flammable wing surfaces, may proceed at first faster than the opening of sprinklers and thus outrun for a time the application of water to the fire.

(4) Water from overhead sprinklers may on some occasions keep the top surfaces of an airplane wetted, thus preserving a shelter under which a fire may spread to various parts of the machine. Under this condition, supplemental equipment, such as hand extinguishers or hose streams, could be brought into use effectively. The use of floor sprinklers might reduce the spread of fire. None of these should be permitted to deprive overhead sprinklers of the water necessary for their effective operation.

(5) Each sprinkler installation should be equipped with suitable alarm devices in order that additional fire-fighting appliances may be on hand as promptly as possible.

(6) Fires involving large quantities of gasoline or similar fuel may not be entirely quenched by sprinklers alone, but would be kept, usually, in a subdued condition, making possible close approach thereto with other means for their subjugation. Suitable additional extinguishing devices should be provided to supplement sprinkler systems for quenching these or similarly persistent fires.

(7) Fires in which several airplanes are ignited simultaneously will usually result in the burning of surface fabrics and the ruin or destruction of some of the structural members of all involved, and may damage airplanes closely adjacent to them.

(8) Fire igniting a single airplane, even under highly favorable conditions for quick spread throughout the machine, is usually controlled by sprinklers so as to cause little or no damage to other airplanes stored close to the one first ignited.

(9) The automatic application of water by sprinklers will generally give good protection to airplane hangars and contents except such of the contents as are involved in the outbreak of fire.

(10) The advantages of a heat-actuated system of open sprinklers such as the one tested are apparent (*a*) in small or slowly spreading fires, (*b*) in buildings having high ceilings or conditions of ventilation causing horizontal drafts, or (*c*) in those fires where the time required for the opening of automatic sprinklers permits the fire to burn out or to get beyond the range of discharging sprinklers.

(11) These tests have indicated that sprinkler systems installed and maintained in accordance with recognized good practice for the protection of this class of property and having an adequate water supply can control most of the fires likely to occur in airplane hangars, therefore serious thought, including thorough economic consideration, should be given to the subject of such installations wherever commercial air transport or other aerial activities are carried on.

The Committee.

Following is a list of the members of the committee and the organizations by which they were designated:

Harry H. Blee, Director of Aeronautic Development, Dept. of Commerce (chairman).
W. S. Garland, Bureau of Aeronautics, Navy Department.
R. W. Hendricks, Underwriters' Laboratories.
Ira G. Hoagland, National Automatic Sprinkler Association.
Maj. Frank M. Kennedy, U. S. Army Air Corps.
W. Laurence Le Page, Aeronautical Chamber of Commerce of America.
Nolan D. Mitchell, Bureau of Standards (superintendent of tests).
H. E. Newell, National Board of Fire Underwriters.
Starr Truscott, National Advisory Committee for Aeronautics.
John Groves, Aeronautics Branch, Department of Commerce (secretary).

Chicago Municipal Airport Fire.

Report by Chicago Board of Underwriters

(Member N.F.P.A.).

Air transport officials were given an opportunity to study at close range the effect of fire on hangars of different types of construction when two hangars and more than thirty planes were burned on June 25, 1930, at Chicago's municipal airport, with a loss estimated at $1,000,000. Starting in the hangar of the Universal Air Lines, the fire destroyed that building and leaped to the adjoining Grey Goose Line hangar, which it destroyed before it was brought under control. A third hangar, that of the Standard Oil Company, was saved through the efforts of the fire department.

Buildings and Occupancy.

The buildings involved in the fire were two large airplane hangars, the Universal hangar on the east and the Grey Goose hangar occupied by the Stout Air Service, on the west. They were located on the north side of West 63rd Street, known as the Chicago Municipal Airport.

The Universal hangar was a one-story ordinary joisted brick building of 31,000 square feet ground floor area. Floor was concrete. Walls were brick. The roof was of wooden construction, with heavy wooden lattice trusses, one-

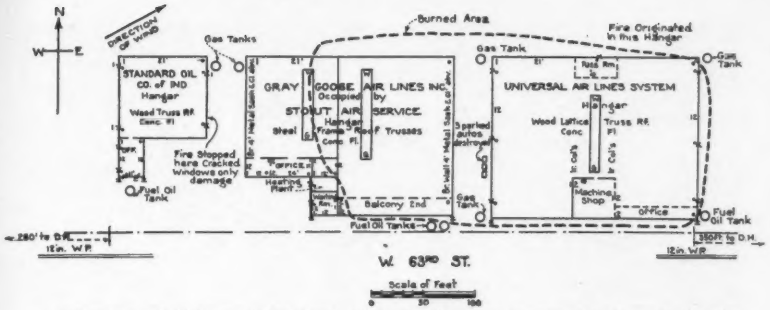


Diagram of Chicago Municipal Airport, showing hangars destroyed by fire June 25, 1930.

inch roof deck and asphalt covering; one standard skylight. This hangar exposed the Grey Goose hangar on the west through unprotected windows at thirty-six feet.

The Grey Goose hangar was a one-story, with a small part two-story, brick building, covering a ground floor area of 28,844 square feet. First floor was concrete, second floor was two-inch plank on unprotected steel. Walls were brick four feet high, metal and glass above. Roof was approved composition on two-inch on six-inch by twelve-inch beams on unprotected steel trusses; two standard skylights.

The hangars were steam heated, with heating boilers located in enclosed rooms having outside entrances. Gasoline supply tanks were buried outside the hangars, with outside fill and vent pipes.

Both buildings were occupied principally as hangars, housing planes varying in size from one to fourteen-passenger capacity. Small portions were used for offices, passenger rooms, and repair shops. A small portion of the second floor of the Universal hangar was occupied by the Pioneer Instrument Company as an office with stock of aircraft instruments. Neither of the hangars was sprinklered.

Private Fire Protection.

Each hangar was provided with a supply of 2½-gallon foam extinguishers, one-quart carbon tetrachloride extinguishers, and a forty-gallon wheeled foam extinguisher. This equipment was used and was of some aid in retarding the fire in the west portion of the Grey Goose hangar, where several large trimotored planes were removed from the building.

Story of the Fire.

The fire originated in a large passenger plane in the Universal hangar. The cause is not definitely known, but the theory has been advanced that static electricity, created while draining the gasoline tank of a large passenger plane, caused the fire. It is common practice to drain the gas tanks of these planes quite frequently in order to remove all scale and sediment from the

Chicago Board of Underwriters.

Front of the two-story portion of the Universal Air Lines hangar at the height of the fire.

tanks. This was being done inside the hangar. One of the attendants started draining the tank and left the plane to get his lunch. While he was absent the fire originated and soon involved the entire hangar.

The fire department was notified at 1:34 A.M., at which time a "still" alarm was received by Engine 127, Engine 88, Truck 40, and Chief of the 26th Battalion. When the Battalion Chief arrived (about four minutes after the first alarm was received) the entire Universal hangar was involved, and the flames had already spread through the roof and windows of this hangar to the Grey Goose hangar, thirty-six feet to the west. As previously mentioned, the exposing window openings between the two hangars were unprotected.

At 1:37 A.M. Box 2452, located at 63rd Street and Cicero Avenue, was pulled. Two-eleven and three-eleven alarms were sounded at 1:41 and 1:46 A.M. The flames spread so rapidly that it was impossible to stop the fire until it destroyed the Universal hangar and most of the Grey Goose hangar.

Firemen directed their efforts in keeping the fire from involving the Standard Oil Company's hangar, 38 feet west of the Grey Goose hangar. The exposing windows of this hangar were wired glass. Some of these windows were cracked by the intense heat, but otherwise the building was not damaged.

It is reported that approximately thirty-three planes were destroyed. The planes consisted of the all-metal type and those covered with fabric. The

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The north end of the Grey Goose hangar, showing the collapsed roof trusses.

planes burned very rapidly, there being little or no difference in the rate of destruction between the metal and fabric planes. The metal planes melted. Most of the above planes were in the Grey Goose hangar, belonging to the Stout Air Service. The larger planes, however, were in the Universal hangar. Several tri-motored planes were removed to safety from the Grey Goose hangar. There were also privately owned planes in the hangars. These were destroyed.

Both of the buildings involved and the planes they contained, excepting those planes removed to safety, were completely destroyed. The west portion of the Grey Goose hangar and the front two-story portion are still intact, but the unprotected steel girders warped and twisted under the intense heat of the burning oil and gasoline, pulling the walls with them. The wood beams in the Universal hangar burned and collapsed, but left the walls still standing.

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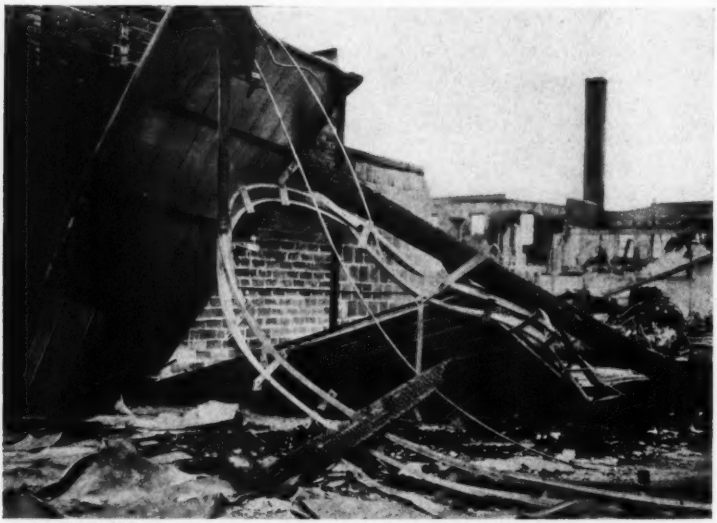
East wall of the Grey Goose hangar. This wall was pulled over when the unprotected steel roof trusses collapsed.

There were three automobiles parked in the clear space between the Universal and Grey Goose hangars at the time of the fire and these machines were totally destroyed. Damage to the Pioneer Instrument Co., on the second floor of the Universal hangar, will, no doubt, be total. Practically no damage other than that resulting to the wired glass windows was suffered in the Standard Oil hangar, due to the work of the firemen in checking the fire at this point.

The water pressure was reported as good; the only unsatisfactory feature in this respect was that the hydrants were spaced far apart, necessitating long lines of hose.

Conclusion.

This was essentially a gasoline fire, occurring in a building of combustible construction, large area, and flammable contents. No automatic means of extinguishment had been provided and there was no opportunity to use first aid hand appliances to advantage. As is to be anticipated under such conditions, the loss was practically total.



American Lumberman.

Interior view of the Universal hangar after the fire.

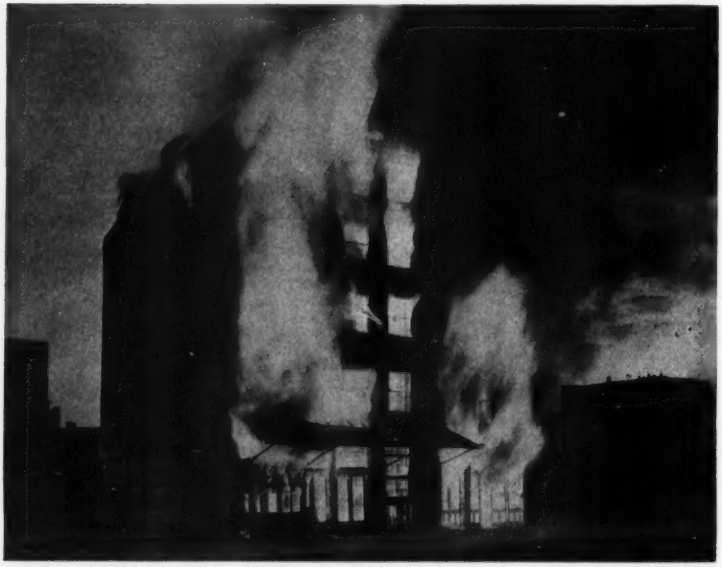
Fire Temperatures and Building Construction.

By Frank Burton,
Consulting Engineer (Member N.F.P.A.).

The reactions of building constructions subjected to fire conditions are so complex that it is difficult to picture in even a moderately exact way what is taking place. Nearly all building fires have as their fuel wood, or paper which is quite similar to wood in many ways. Hardwood in a dry condition consists of about 50 per cent carbon, six per cent hydrogen and the rest oxygen, with a trace of nitrogen and ash. When it burns it is said to produce from 6000 to a little over 8000 British Thermal Units per pound. By a British Thermal Unit, or B.T.U., we mean the quantity of heat necessary to raise one pound of water one degree Fahrenheit. In determining this value the wood is completely burned in a steel bomb by means of oxygen, and all the products of combustion are cooled to room temperature. In an actual fire the wood is burned by combining with the oxygen of the air, and the products of combustion, carbon dioxide and water, as well as a great mass of nitrogen in the air, which is nearly four times the weight of the oxygen, must be heated to a high temperature, and in escaping carry away most of the heat. In burning coal in a well-regulated furnace the escaping gases should contain about 14% of carbon dioxide, but often carry much less. In burning wood without a grate or any regulation of draft it appears that the carbon dioxide content of the gases of combustion does not usually carry over 10% of carbon dioxide, and upon this basis I have estimated the amount of heat carried away at various temperatures. Assuming that good average hard wood will produce 8130 B.T.U.'s gross, which is a high estimate, the products of combustion will carry away 6188 B.T.U.'s if the temperature of the escaping gases is 1700 degrees. It should be noted that the temperature of these gases must always be higher than the floor or column being heated, otherwise the heat will not flow into the building construction.

At the start of a fire the outgoing gases will be much cooled by the cold ceiling and walls, but as the temperature of these rises the temperature of the outgoing gases must rise, carrying off an increasingly large percentage of the heat. Under the above assumptions the distribution of heat at various temperatures of outgoing gases would be:

Deg. F. Gases	Heat in Gases B.T.U.	Per Cent of Total Heat
600	2151	26.5
1000	3619	44.5
1400	5087	63.0
1800	6555	36.8
2200	8115	99.8



About 2200° F. is in general the limit of temperature in an uncontrolled wood fire.

Under the above assumptions the temperature of the fire cannot rise above about 2200° F. Actually local areas of temperature up to 2400° have been observed in a test fire,* but this is due to the fact that the combustion was more perfect than we have assumed herein; that is, the carbon dioxide content was over 10%. In general, however, 2200° F. is about the limit of temperature observed in an uncontrolled wood fire.

Now let us see how much wood or similar combustible there is in a building. If a building is divided into moderate sized rooms, such as a hotel or apartment, with wood stud partitions, and has wood floors, floor-joists and lath, it will contain by actual computation about 19 pounds of combustible per square foot of floor area, of which 14 pounds is in the structural elements, partitions and lath, and five pounds in the hardwood floor, finish and trim. The contents will vary from five pounds or less for apartments and hotels up to 10 pounds or thereabouts for offices, and for stores, factories and warehouses there may be almost any value up to the capacity of the floor construction. Heavy occupancy buildings should be considered separately, so we shall for the present confine our discussion to buildings containing only about 10 pounds of combustible contents.

Let us consider that a wood joisted building with 10 pounds of contents is ignited. We have 29 pounds of combustible for each square foot of area

*Fire Tests of Brick Joisted Buildings. QUARTERLY, Vol. 22, No. 1, p. 62.

and practically nothing to absorb the heat produced because the unburned part of the wood, being a very poor conductor of heat, absorbs very little. The temperature must therefore rise very rapidly and soon attain a temperature near the maximum of 2200° F. for combustion, resulting in ten per cent carbon dioxide, or slightly higher with more perfect combustion. This is just what was found in a practical test with an unplastered building.* If, however, this building had been divided into small rooms and plastered there would have been about 40 pounds of plaster per square foot. In order to heat this plaster to approximately the temperature of the outgoing gases, enough heat would be absorbed to reduce the temperature about 200° F.

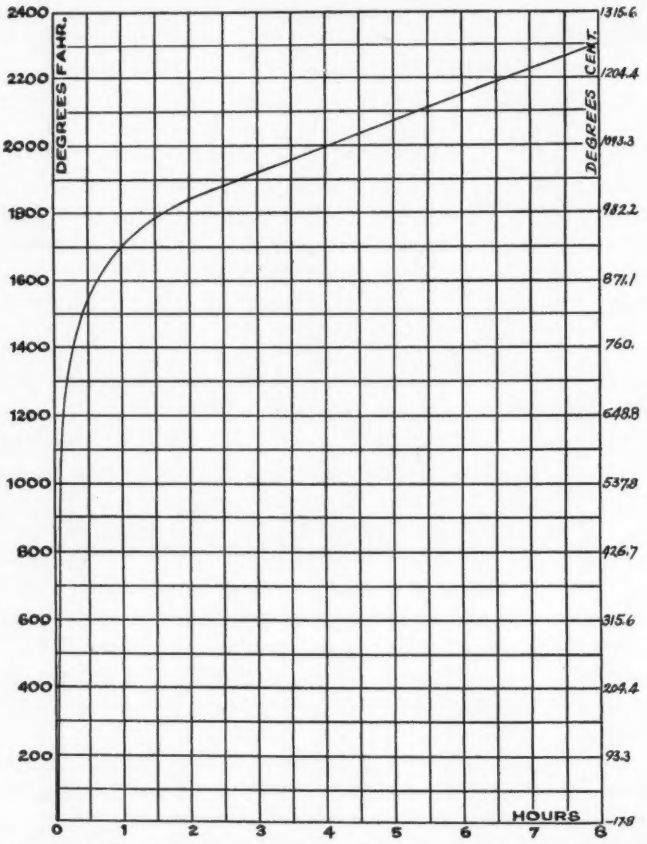
If now we replace the floor joists, sub-floor, lath and partition studs with incombustible materials the available combustible will be reduced to the floor finish, trim, doors and contents, amounting to about 15 pounds per square foot, while the relatively rapid heat absorbing surfaces will become so numerous that no great temperatures can be obtained.

In the Columbia University testing house, which is about 300 square feet in area, it has been found necessary to burn 37 pounds of hard wood per square foot of floor area to perform a four-hour standard test. The temperatures attained are approximately the same as in the standard A.S.T.M. fire test. In this test the temperature is supposed to be 1700° F. at the end of one hour, 1850° at the end of two hours, and 2000° at the end of four hours. Dr. S. H. Ingberg of the U. S. Bureau of Standards gave it as his opinion after extensive practical tests at Washington that 10 pounds of wood or similar combustible were required to give the effect of a one-hour fire, 15 pounds for a 1½-hour fire, 20 pounds for two hours, 30 for three hours, and 40 pounds for a 4½-hour test.*

It would appear from these data that the burning of the 15 pounds of combustible, consisting of contents and trim, would not be a very serious matter. It would resemble a 1½-hour standard fire if burned in a standard test house, but when burned in an apartment or hotel, with many partitions each absorbing heat, it is apparent that the temperatures cannot rise high.

If we ignite the contents of a room in such a building there will be a period of time which may be shorter or longer, depending upon the combustible present, during which the fire will smolder, and most of the heat produced will be absorbed by the cold walls, ceiling and floor. When the surface of the room and the air reach some temperature about 500° to 550° F. the fire will become general and the temperature of the gases of combustion will rise rapidly to about 1700° or 1800° F. The outer surface of the walls and floor will now become quite hot from the radiant heat, and heat will be absorbed as rapidly as the material of the walls and partitions will permit. If the outer surface is highly conductive, much heat will penetrate and comparatively little

*Tests of the Severity of Building Fires. QUARTERLY, Vol. 22, No. 1, p. 43.



The Standard Time-temperature Curve. Furnace temperatures in standard fire tests are controlled in accordance with this curve, and ratings in hours of fire resistance are determined accordingly.

will be carried away by the products of combustion. It is very difficult to make anything approaching an exact analysis of the conditions because there are so many factors involved, some of which are not well understood. In a general way it is, however, easily seen that the conductivity of the surface coating of the walls and ceiling is of the greatest importance. If the ceiling were to be of bare steel its temperature would rise rapidly, remaining at all times only a few degrees below the outer surface. As a consequence the surface and therefore the gases of combustion would be greatly cooled and a large proportion of all the heat of combustion would be absorbed by the ceiling. If the surface were of concrete or a cement plaster, which is relatively

highly conductive, the absorption of heat, while much inferior to iron, would be considerable. A sanded gypsum plaster would be much better, but a fiber gypsum plaster or cinder concrete would be still superior. The heat conductivity of a stone concrete is about ten times as great as a fiber gypsum.

The heat insulating values of a thin surface, say one-half inch thick, profoundly affect the temperature of the outgoing gases and cause a much larger part of the total heat of combustion to escape without heating the construction. In fire testing this point is not important because the engineer continues to add fuel to the fire in order to maintain the desired temperature until the time required by the test has elapsed. In practice, however, if the inner surface of the room is highly heated, the contents will soon be consumed, with most of the heat leaving in the gases of combustion and only a little penetrating to the interior of the construction.

Building codes almost universally refuse to give consideration to plaster in construction, and it appears to me that this is a very great mistake. The Bureau of Standards tests* on plastered and unplastered walls showed a great variation in conductivity, plastered walls showing much lower conductivity, but this is only part of the story. If fire tests were to be made with a given quantity of combustible rather than a given time of burning, the results would, I believe, be even more noticeably different.

In heating various materials it is found that for each a particular quantity of heat is required to raise the temperature of one pound of the material one degree and is known as the specific heat. For iron and steel this value varies, but averages .14 over the range from room temperature to 1100° F. For concrete, brick, mortar and similar materials this value averages just about .20.

Let us see if we can trace in an approximate way the actions taking place when a thin sheet of fire-resistive material is exposed to heat. A steel column weighing 31.5 pounds to the linear foot is encased in an inch of metal lath and cement plaster. The perimeter of the casing is 3.67 feet, so that for each 31.5 lbs. of steel there are 3.67 square feet of outer surface exposed to the gases of the test furnaces heated to say 1500° F. averaged over the heating period. If the steel column is loaded with its full designed load it will fail by softening at about 1100° F., or about 1040° above the starting point. Now we will multiply 1040° by 31.5 lbs. by .14 (the average specific heat of iron) and obtain 4600 B.T.U.'s as the required amount of heat to cause the steel column to fail. Also there are 3.67 x 12=44 pounds of plaster to be heated, so that the outside will reach a temperature of say 1300° and the inside 1100°, or an average of 1200°, which is 1140° over that at the start. Multiplying 44 pounds by 1140° by .20 (the specific heat) we have 10,000 B.T.U.'s required to heat the plaster, or a total of 14,600 B.T.U.'s must be absorbed by 3.67 square feet of area equal to 4000 B.T.U.'s per square foot. In order

*Fire Resistance of Hollow Tile Walls, Research Paper 37, U. S. Bureau of Standards.

to determine how much heat will be absorbed by the plaster surface we must know the exact surface temperature, since radiation and absorption is a fourth power function. It is very difficult to determine this temperature, and we must therefore refer to test data to find an approximate answer. We find that such a column fails* in a fire test at almost exactly one hour, disregarding the first few minutes while the furnace temperatures were building up. Therefore the plaster absorbed 4000 B.T.U.'s per square foot per hour and retained 2730 B.T.U.'s to heat the plaster, passing 1270 units on to heat the steel.

As a method of protecting this column the use of metal lath and plaster was not satisfactory. Had the plaster been gypsum containing fibrous material the heat would have passed much more slowly. Had the column been of larger section the temperature rise for this amount of heat would have been much slower, that is, the column would have lasted a much longer period. Suppose now that the space behind the column were filled with concrete and ignore any insulating value it might have. About 100 pounds of concrete would have been required per foot. If all of the heat that penetrated the plaster had been distributed between the steel and this concrete the final temperature would have been only about 250° F. It is evident that many factors besides the thickness of protection must be taken into account. It is quite apparent that the mass of heat-absorbing material is quite as important as the rate of transmission of heat through the exterior covering.

The immediate interior surface of light occupancy buildings should be given serious consideration instead of dismissed as of little consequence. A layer of loose cloth with some fragile floral decorations inside an assembly room of otherwise satisfactory construction caused the death of 22 persons in Detroit a short time ago without serious damage to the structure.† A building with timber walls and floors, but with an incombustible inner surface, could never have been the cause of such loss of life with the exits that were available.

*Technological Paper 184, U. S. Bureau of Standards (Test No. 25).
†QUARTERLY, Vol. 23, No. 2, p. 115.

Note.

This article is extracted from an address by the author at the 1930 meeting of the Building Officials' Conference. A second article further developing the thought of this paper is to be published in an early issue of the QUARTERLY.—Ed.

High Tension Wires and Hose Streams.

Compiled by H. S. Walker,
Field Engineer, N.F.P.A.

High potential electric wires present a problem of considerable interest in modern fire fighting. From the earliest days of the adaption of electricity to commercial purposes there has been a conviction that it is highly dangerous to play a stream of water on a charged wire. The daily press has, from time to time, recorded instances where firemen have received electric shocks while fighting a fire. In almost every case these shocks have been attributed to the conductivity of the stream of water coming in contact with power or light wires. The popular idea is that the electric current is conducted down the stream to the fireman at the nozzle with injurious and possibly fatal results.

The records of some of the larger fire departments, however, fail to show any great number of fatal or serious results due to the playing of a hose stream against a high tension line, although reports of slight shocks are fairly numerous. This record may be due to the fact that fire departments have taken extraordinary precautions against possible accidents, and it may be partly due to the fact that higher voltage lines, where overhead in urban districts, are invariably at greater elevations and at greater distances from buildings. Electrical fatalities in connection with fire fighting have been for the most part due to accidental contact with wires or electrical equipment, or to men stepping into water charged by fallen wires; this hazard is obvious.

In an attempt to solve the problem of the conductivity of hose streams a number of experiments have been made. These tests, while not in agreement in all particulars, are indicative of the relative hazard to life under varying conditions. The general conclusion to be drawn from them seems to be that the hazard to life has been somewhat overrated and that relatively little hazard exists with the ordinary hose stream. It should be noted, however, that these tests have been limited to circuits carrying 30,000 volts or less, and where transmission lines of greater voltage are involved a special problem is presented calling for more than ordinary precautions.

Seminza's Experiment.

One of the earliest of these experiments was that made by Guido Seminza at Milan, Italy in 1901. His tests were made with both direct current and alternating current, and were conducted both in the laboratory and under conditions similar to actual fire conditions. In each instance the results were found to be almost identical.

From these experiments Seminza drew the conclusions that it is practically impossible for a fireman to receive a shock from a wire at low potential unless the nozzle is brought to within about an inch of the conductor, and only in this case when the fireman holds the nozzle in one hand and a ground

conductor with the other and is thoroughly wet. It is obvious, however, from the experiments that as the potential increases or the volume of the hose stream increases the distance through which the shock is perceptible is in some degree increased. This is indicated by the following paragraphs taken from the account of the experiments which appeared in the *Electric World and Engineer.*

The fireman climbed a wooden structure, with one hand grasped a wire having a good connection to the track rail, and with the other hand held a nozzle which directed a jet on to the trolley wire.

With a jet from a ½-inch nozzle under such pressure that the column of water reached its destination without breaking, the first sensation was at 40 volts with the nozzle about one inch from the conductor. With the increase in voltage the distance gradually increased, and at 500 volts it was about 7½ inches.

The maximum value of the voltage used was 3600 volts, and at this tension a sensation was perceptible at a distance of about ten feet. A person of average sensibility can endure the sensation from this voltage without great inconvenience up to a length of jet of about three feet.

The section of the jet, however, notably changes these distances. Thus with a 2-inch jet the shock is perceptible for 500 volts at eight feet. With 3600 volts it is quite strong at twenty-four feet, and at thirteen feet it becomes quite intense and nearly reaches the limit at which it may be supported by a person of average sensibility.

The form of jet has a great influence, which can easily be understood. A continuous jet must offer very much smaller resistance to the current than one that breaks or scatters. This was quite clearly shown by the experiments. With equal length of water jet the sensation is stronger the smaller the velocity (pressure) as with the smaller velocity the stream is much more compact. This explains why the shock increased less rapidly than the voltage, for the greater the distance the less easy it is to maintain a compact jet.

Hoxie's Experiment.

In the summer of 1907 several interesting experiments were made by the late F. J. Hoxie (Member N.F.P.A.), which were reported in the QUARTERLY for April, 1908 (Vol. 1, No. 4). These experiments were conducted using a potential of 3500 volts. One side of the circuit was connected to a loop of No. 12 bare copper wire about two inches in diameter. The other side was connected to the underground water pipes. Fifty feet of two and one-half inch cotton rubber-lined hose was attached to a hydrant, and provided with a standard one and one-eighth inch brass nozzle. The water was throttled down so as to make a continuous and nearly solid stream. The end of the nozzle was fastened in porcelain cleats 12 feet from the loop of copper wire. On the floor near the nozzle was placed a sheet of lead in metallic connection with the water pipe system.

Having first poured water on the sheet of lead to insure good contact, Mr. Hoxie stood upon it with his bare feet and grasped the nozzle firmly with both hands, they also being wet. Most of the current conducted by the hose stream passed through his body to the other side of the circuit, as the resistance of the water in the 50 feet of hose stream between the nozzle and the hydrant was very great compared with that of the human body.

The shock experienced was very slight. The nozzle tip was changed to one and one-quarter inches, whereupon the sensation was somewhat increased, but was not unpleasant.

The water used was town drinking water containing 23 milligrammes of mineral matter per liter, and the resistance of the hose stream was about two million ohms as calculated from the measured conductivity of the water. Well water in this location has a conductivity about four times the above. In a lime region the surface waters would probably have a conductivity five or six times the above, and well waters might have ten or fifteen times. The conductivity of sea water would be about 200 times as great.

It would seem that not much is to be feared from ordinary lengths and sizes of hose streams supplied with city water when applied to 2000-volt wires. With sea water or streams from chemical engines the results would be different and dangerous shocks might result.

Pennsylvania R.R. Experiments.

In August, 1908, a series of tests were made under the direction of officials of the Pennsylvania Railroad Company at Altoona, Pa., to determine, for various voltages, the distance from live wires at which streams from fire hose and chemical extinguishers might be played on the same without injury to those handling the hose. The results of these tests appeared in the QUARTERLY for October, 1908 (Vol. 2, No. 2).

In order to determine definitely what hazard, if any, existed for firemen when they were compelled in line of duty to play water from fire streams on live wires at various potentials, arrangements were made so that circuits of 525, 2300 and 4600 volts respectively were available. The 525-volt line was a direct current trolley wire, while the 2300-volt and 4600-volt lines were fed from alternating current generators at the Altoona Car Shops. One side of each of these circuits was thoroughly grounded and the fire stream played on the other side, which was suspended in the air and thoroughly insulated. A suitable voltmeter was connected between the nozzle and ground to enable the difference of potential between the nozzle and ground to be noted in each case. The following results were obtained.

Voltage to Ground. 5/8-inch Nozzle.

Voltage on Wire	Distance of Nozzle from Wire	Potential Between Nozzle and Ground
525	7 ft. 5 in.	20 volts
525	4 ft. 9 in.	38 volts
525	3 ft. 7½ in.	60 volts
525	2 ft. 2 in.	70 volts
525	0 ft. 7½ in.	210 volts

These results showed that the nozzle could be handled without discomfort up to a point between three and four feet from the wire when those holding the nozzle were standing on the ground. It could have carried much nearer without harm, but would probably have caused some discomfort.

In the tests with voltages from 2050 to 4600, with distances between nozzle and wire of from 3 to 10 ft., no measurable deflection could be obtained on the voltmeter, but upon touching the nozzle with the hand when standing on the ground a slight effect due to static electricity was noted. The lack of definite indication of voltage was presumably due to the characteristics of the voltmeter; these tests are not comparable with the 550-volt direct current tests summarized in the foregoing table. In none of these tests was the amount of current flow recorded and for this reason the data have limited significance.

Experiments were also made with streams from hand chemical extinguishers, and it was found that when a solid stream is played on a high potential wire it becomes a source of danger to one holding the extinguisher. For instance, the nozzle of an extinguisher was held at a distance of nine (9) inches from a 2050-volt alternating line. The difference of potential between nozzle and ground was 1500 volts when the extinguisher was insulated from the ground.

Cambridge Experiment.

Another interesting test along similar lines was made a few years ago in Cambridge, Mass., by Mr. T. C. O'Hearn, city electrician, with the coöperation of the fire department, which brought out further interesting facts. The following data have been extracted from the report of the test.

A bare copper wire was strung between two poles and connected to the high tension side of a transformer. The other side of the transformer was connected to the ground with a low resistance transformer in the lines. A bank of lights was shunted across the transformers to indicate visually when the current was on. The low tension side of the transformer was connected to the low tension or secondary side of a second transformer whose high tension side was connected to the 2300-volt mains. These connections were made to prevent grounding the electric light company's service lines.

A nozzle set in a holder was grounded with a low resistance ammeter between the nozzle and the ground. This ammeter would show the current, if any, that would flow from the nozzle directly to the ground, and would indicate the amount of current flowing through a man's body when holding the nozzle. If any current flowed, part of it would go through the circuit formed by the water in the hose and the water pipes. The ammeter in the line would show the total current flowing. The difference between the two readings would give the current flowing through the water in the hose. The station ground of the electric light company was used, so there was no question of resistance of the ground connection.

A 1¼-inch nozzle was used with a hydrant stream from the city main. The nozzle was approximately 25 feet from the wire, and a good solid stream was directed against the wire. The voltage in the wire was 2240 volts. There was no indication of current flow in either ammeter. A voltage reading showed a difference of potential between the nozzle and ground of 20 volts.

Salt water was then used with the same results. The stream in this case was not so solid, however, and the results cannot be construed to mean that the use of salt water would give the same results as with fresh water, because there is no question that salt water is a better conductor.

A test was made to determine the conductivity of the city water. In a tank of water with the terminals one foot apart, a 5 amp. fuse was blown in three seconds, with 1000 volts on the line. The relatively poor conductivity of the fire stream, therefore, was purely due to the fact that the solidity of the stream was not so great as appeared to the eye, and also because the cross-section of the stream was small compared with that of the water in the tank.

From this test the conclusion may be drawn that up to 2300 volts, with lines twenty-five feet or more from the ground, a fire stream may be directed from the ground against a charged wire with but little danger of a severe shock or fatal results.

University of Ohio Experiments.

While the foregoing experiments seem to indicate an absence of danger to life in directing a hose stream upon a high tension line at usual distances, data obtained under the direction of Professor F. C. Caldwell at Ohio State University show just to what extent the danger does exist.

These tests were made to represent as nearly as possible actual fire conditions, using standard fire hose and $1\frac{1}{8}$-inch and $1\frac{1}{2}$-inch nozzles. The investigation took the form of measurements of the resistance of the stream of water between the nozzle of the hose, which was grounded, and a charged copper wire strung horizontally above the ground. The voltage, water pressure and length of stream between the nozzle and the wire were varied and the effect of each upon the resistance of the stream was studied.

Variation of the voltage produced no well-defined effect upon the resistance of the stream within a range between 5000 and 30,000 volts. Increase of water pressure, however, gave increased resistance. This was slight for 6 and 10-foot stream lengths, but quite marked for 15 feet. This appears to be due to the fact that with the higher pressures the stream is less solid, especially at greater distance from the nozzle, and hence a poorer conductor.

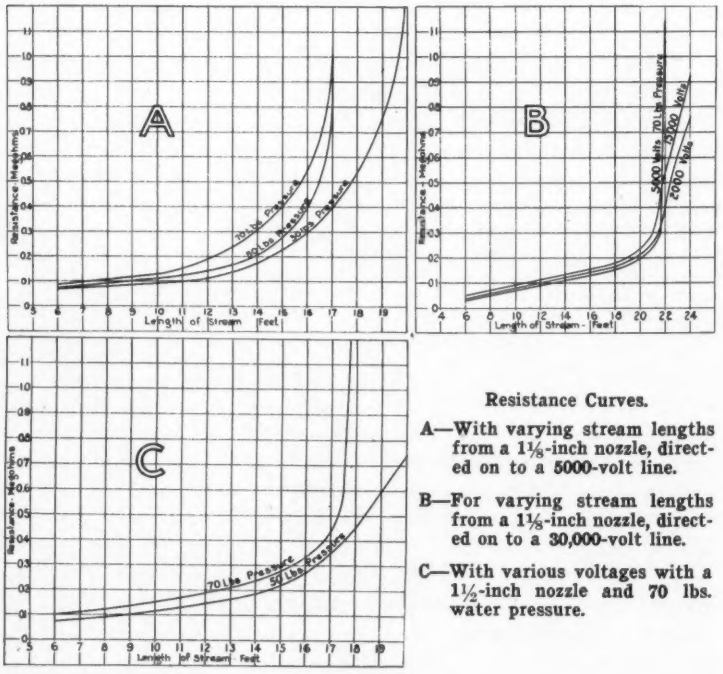
The striking and interesting results obtained from the tests came with the variation of the length of the stream. In these tests (as indicated by Figures A, B and C) the resistance increased gradually up to a critical length, which for the $1\frac{1}{8}$-inch nozzle was about 17 feet, and for the $1\frac{1}{2}$-inch nozzle 20 feet. Beyond this point the resistance increases rapidly and approaches infinity. This critical length was found to be slightly lower for higher pressures, although the difference was almost negligible. Observation of the stream of water indicates the reason for the critical length. It is the point where the stream loses its solidity and breaks up into a mass of separate water drops.

It is not voltage that kills, but amperage. Voltage merely provides the means of forcing amperage through the body. As bearing on these experiments, it should be noted that a current of .02 ampere is quite painful to most persons, while .05 ampere is, while not fatal, at or beyond the limit of human endurance. The volume of current necessary to kill is seldom less than .1 ampere and usually much more.

The resistance at varying voltages was determined by the experiments for varying stream lengths. From the results thus obtained and from the application of Ohm's law, in which $I = \frac{E}{R}$, where I=amperage, E=voltage and R=resistance in ohms, the following table was worked out indicative of the effect of stream length on resistance. Professor Caldwell believed that 30,000 volts would meet the maximum voltage which firemen would ordinarily have to meet, hence the table has been computed in that basis.

Distance of Nozzle from Wire	30,000 Volts Resistance	30,000 Volts Current Flowing
8 feet	70,000 ohms	.43
12 feet	100,000 ohms	.32
16 feet	135,000 ohms	.22
20 feet	200,000 ohms	.15
22 feet	430,000 ohms	.07
24 feet	770,000 ohms	.04
26 feet	1,100,000 ohms	.03

Now what do these currents mean in terms of danger to the men at the nozzle? It has been indicated that up to 0.1 ampere is a safe current from a life standpoint, but beyond that might be dangerous. It is therefore evident



Resistance Curves.

A—With varying stream lengths from a 1⅛-inch nozzle, directed on to a 5000-volt line.

B—For varying stream lengths from a 1⅛-inch nozzle, directed on to a 30,000-volt line.

C—With various voltages with a 1½-inch nozzle and 70 lbs. water pressure.

from an examination of the table that there is very little danger in directing a fire stream against a wire carrying 30,000 volts, 25 feet or more away from the nozzle. There is probably little danger up to within ten feet, but this is problematical, as the condition of the individual directing the stream might make a difference. A person suffering from heart trouble might be electrocuted by a current which would not injure a sound, healthy individual.

The conductivity of water in Ohio is several times that in most sections of the country. It is many times the conductivity of average New England drinking water. It would appear, therefore, that in these other sections a 16 or even a 10-foot distance would be relatively free from danger or even discomfort.

Since high tension circuits should always, when near building, be carried on poles that would bring the lines much more than 25 feet from the ground, it would seem that little fear of injury to firemen from this source need be entertained so long as the poles are of proper height and the fireman is working from the ground. If, however, he is working from a metal framed ladder, or is using a tower which is not well grounded through the truck, and which would bring the nozzle into close proximity to the wire, a dangerous shock through the stream might be received.

It may be asked whether the fact that the nozzle is grounded through the stream of water in the hose would not keep its voltage so near that of the earth that even with the short stream length there could be no danger. With this point in mind the resistance of the path from nozzle to ground through the water in the hose when the latter was thoroughly insulated from the ground was investigated and found to be about 150,000 ohms per hundred feet, from which it would appear that such a ground connection could not be depended upon to shunt much of the current around the man holding the nozzle. A good ground connection to a truck which is itself well grounded to a near-by hydrant would, however, make handling a nozzle safe, even if the current flow much exceeded 1 ampere, due to rather close proximity of the nozzle to a high voltage line, as might occur with a water tower raised near such lines.

From the combined results of the various tests, it is conclusive that a shock may, in some cases, be obtained from a nozzle while playing on a live wire, but that the danger to life is relatively small. The severity of the shock, if any, will depend on

(1) The voltage in the wire. Higher voltage forces more current through a body, hence greater amperage and increased shock.

(2) The distance between the nozzle and the wire. The greater this distance the greater the resistance of the stream and the less severe the shock.

(3) The conductivity of the water. The more impure the water and the greater amount of salt in it the greater the conductivity of the stream.

(4) The size of the stream and the pressure. The conductivity of the stream varies directly with the diameter and inversely with the pressure. Beyond solid stream distances the resistance is very high.

From these conclusions it appears that in the event it becomes unavoidable that hose lines must be operated in the presence of high tension lines, there are two factors that may increase the safety of the men handling them: First, a high nozzle pressure to give the greatest working range possible, and second, the use of small nozzle tips to partially "fan" or break the streams and thus decrease their conductivity.

The following table has been worked out on the basis of permitting a flow of current through the body which, while unpleasant, would not be dangerous. It may serve as a guide in determining under given conditions the minimum distances at which a nozzle must be kept to safeguard the man holding it.

Voltage	Safe Distance 1⅛-inch Nozzle Feet	Safe Distance 1½-inch Nozzle Feet
1100	6	9
2200	11	16
3300	15	22
5500	18	27
6600	19	29
11000	20	30
22000	25	33
33000	30	40

The above figures apply to fresh water only. From the conclusions reached by Mr. Hoxie if salt water (sea water) were being used, distances two hundred times as great as the above should be used; streams of such length would, of course, be impracticable. Due, however, to the fact that sea water would undoubtedly be used under pressure as pumper streams, it seems reasonable to assume that the streams would, while satisfactory for fire fighting, lack solidity. This would decrease their conductivity so that with $1\frac{1}{8}$ or $1\frac{1}{2}$-inch nozzles the safe distances for sea water would be but little greater than for drinking water. A table for salt water might be as follows:

Voltage	Safe Distance 1⅛-inch Nozzle Feet	Safe Distance 1½-inch Nozzle Feet
1100	25	30
2200	25	30
6600	30	35
11000	30	35
22000	30	40
33000	35	45

As to voltages above 30,000, few, if any, experiments have been made. A few years ago, however, a questionnaire was sent out by one of the affiliated companies of the National Electric Light Association containing the question, "Is it safe to direct a fire stream against a 150,000 or 44,000-volt conductor?" Two of the replies to the question are given below.

"It is not advisable to direct a stream of water against high potential circuits, and by high potential is meant, in this instance, voltage of 20,000 and above. Whether such action is safe or hazardous depends, for a given voltage, upon the resistance of the stream of water

Factory Mutual Record.

Testing conductivity of extinguisher streams. Water, soda-acid, calcium chloride, or foam applied to live electrical equipment will cause arcing and may produce dangerous short circuits. At close range these streams may conduct enough electric current to seriously shock the operator.

which is dependent upon the length, cross-section and pressure of the water stream and the purity of water. As these properties of the water and water stream are extremely variable, and not generally known at the time, playing water into a high tension line should—for the sake of safety—be considered dangerous, if not hazardous. I have seen firemen play water into a 40,000-volt line without the slightest shock to the firemen. I do not know the size of the nozzle used nor the water pressure, but the water was very pure. The height of the conductors from the ground was about 40 feet."

"It is unsafe to direct a fire stream of water against a high voltage conductor. If the water is pure no harm will be done, but if impure it will carry current to the person holding the nozzle. The West Jersey Seashore Ry. made some tests a few years ago by squirting a fire hose over their 33,000-volt transmission line without getting a perceptible amount of current back over the stream. When current is on the line the danger of the person directing the stream receiving a shock is evident if the water be impure."

A severe and perhaps dangerous shock may be received when using an ordinary soda-acid extinguisher on a high tension line. Experiments with streams from this type of extinguisher indicated that when a solid stream was played on a high potential wire it became a source of danger to the one holding the stream.

A few years ago a series of tests were made by the Inspection Department of the Associated Factory Mutual Fire Insurance Companies (Member

N.F.P.A.) to illustrate and determine the effects of different extinguishing agents on live electrical equipment, and the actual danger attending the use of the various types of extinguishers.*

The first series of tests was made by connecting a metal plate to one side of a 550-volt alternating current circuit, and the nozzle of the extinguisher, through a 110-volt lamp, to the other side in such a manner that the stream from the extinguisher would complete the circuit. The general arrangement is shown in the cut.

Conductivity tests were then made by using first a stream of water, and later the following types of extinguishers: soda-acid, foam, non-freezing filled with calcium chloride, and carbon tetrachloride. The lamp would burn brightly when the calcium chloride nozzle was three feet or less away from the plate, and also when the soda-acid nozzle was six inches or less, but would not burn at all through the streams of foam, carbon tetrachloride, or water.

More delicate tests were made with the same apparatus, but using a voltmeter in place of the light. The calcium chloride stream conducted a small current six feet from the plate, soda-acid stream four and one-half feet, foam five inches, and water two inches. Carbon tetrachloride was a nonconductor at all distances.

A second series of tests to demonstrate in another way the conductivity of the extinguishing liquids was made by directing the various streams on to switchboard panels having bare live bus-bars and cut-outs connected to 220-volt direct current and 550-volt alternating current circuits. Carbon tetrachloride had no effect whatever, and water merely caused a few sparks on the surface of the 550-volt panel.

When the soda-acid stream was used a considerable leakage of current took place, as evidenced by sparking on the panel. Foam piled up to a considerable depth on the busses and then fell off in masses, causing continual sparking and arcing, which eventually flashed across from one bus-bar to the other and blew the fuses. The leakage when calcium chloride was used was also sufficient to blow the fuses.

These same tests were repeated on a switchboard panel of wood with similar results, except that the arcing caused by the streams from soda-acid, calcium chloride, and foam extinguishers was more severe, and was sufficient to badly char and ignite the wood.

These tests, as well as practical experience, have demonstrated that:

(a) There is no danger in fighting fire in the vicinity of electrical equipment with any form of extinguisher, unless the stream actually hits live parts of the equipment.

(b) On the live apparatus itself, water, soda-acid, calcium chloride, or foam will cause arcing and may produce short circuits which would seriously damage the apparatus.

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*These tests did not include carbon dioxide for they were made prior to the general use of CO_2 in portable units for fire fighting. There is obviously no danger in the use of CO_2 on electrical equipment.—Ed.

(c) When these extinguisher streams are used at close range, they may conduct enough electric current to shock the operator sufficiently so that he would stop fighting the fire. Above 550 volts, the results might be fatal.

Fire Record.

Information relative to actual experiences of men who have been called upon to fight fire in the vicinity of high tension transmission lines has been difficult to obtain. Of the following instances, the first four have been furnished by W. W. Stephen, Chief of the Southern Manganese Corporation, Anniston, Ala. (Member N.F.P.A.), one has been extracted from the *Electrical World,* and the others have been taken from N.F.P.A. Fire Record files.

CASE 1. The city fire department was called to an industrial plant where a roof was on fire on a frame building, a few feet from a 22,000-volt transmission line.

The first company to arrive laid a line from a hydrant inside the plant, but a plant official attempted to restrain the man at the hydrant from starting the water, protesting that there was danger from the high tension wires. The fire department officer in charge ordered water started and the fire was quickly extinguished without shock or injury to pipemen. It is doubtful whether solid stream touched wires, although they were splashed by spray.

CASE 2. The city fire department was called to a fire in an industrial plant where lightning arrester equipment was involved.

This apparatus consisted of several electrolyte and oil tanks on an elevated platform in the midst of a network of steel towers and wires carrying twenty-two thousand volts. A grass fire had ignited board fence enclosure, and this and platform were completely involved. One of the arrester cylinders exploded, scattering burning oil, the flame momentarily going up as high as the steel towers, with a terrific detonation of arcing through the heated air.

The department chief, arriving first, took the two 2½-gallon foam extinguishers that were carried on his car and emptied them on the burning platform, blanketing the surface around the unexploded arrester cylinders and checking the fire considerably.

The first company arriving laid line from a plant hydrant, but were delayed by having to force hose house door. Meanwhile a second company arriving pulled off chemical line and operated it. This truck carried chemical tank from which the solution was expelled by compressed air. As this tank was filled with ordinary fresh water the use of the stream it supplied was much safer than that of a straight chemical line would have been, and by the time the 2½-inch line was laid the fire was under control. No difficulty was experienced.

CASE 3. Fire occurred in the upper portion of a frame and tar paper covered structure, two stories in height, forty by twenty-five feet, which con-

Wires on poles ordinarily present little or no hazard to firemen handling hose streams from the ground.

tained a complicated electrical installation that carried a 50,000-volt current.

The roof and portion of upper story were almost instantly involved, the flames going high in the air. The plant department had two good hydrant streams operating within a minute, despite the fact that one hydrant, situated near the building, was inaccessible on account of heat.

During about two minutes that elapsed before high tension current was cut off a terrific amount of arcing and short circuiting occurred in upper part of building, which was repeatedly swept by streams, with no harm to pipemen.

CASE 4. A one-story tar paper structure, fifteen by twenty feet, containing an experimental installation, was ignited, presumably from a short circuit, and instantly involved.

The heat of the fire broke insulators of a forty-four thousand volt transmission line overhead and these conductors fell down on the fire, making a fearful display. There were also situated within ten feet of the fire three oil filled 3500-kilowatt transformers.

The plant department quickly had two hydrant streams in operation, using nozzle tips one inch and seven-eights of an inch in diameter. These industrial plant firemen, in the face of this combined electrical and explosion hazard, held their ground several minutes until the current was cut off, keeping one stream on the fire and the other on the transformers, at a distance of about forty feet.

During this time the pipemen received repeated and severe shocks that nearly overthrew but did not severely injure them.

CASE 5. At a fire on an elevated railway structure in New York City a fireman was stationed on the platform between the two tracks, using a hose stream. The fire was underneath the third rail. Part of the line he played on the third rail in which current was flowing. While so doing he experienced no shock.

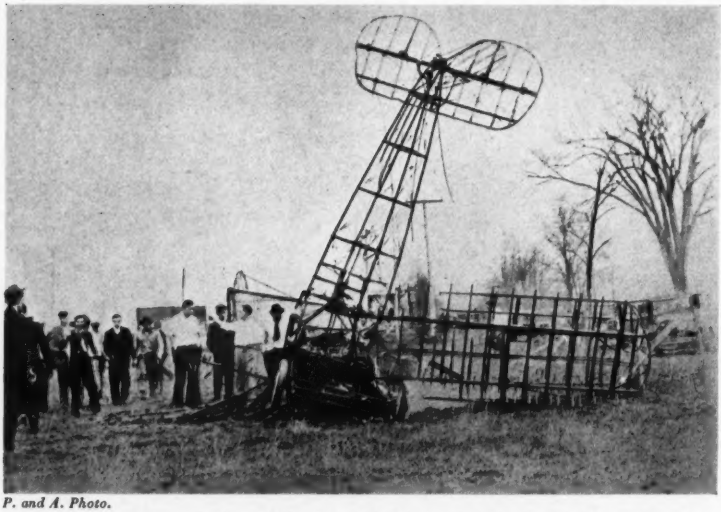
When the fire was out he signaled back to shut off the water. As the force of the stream diminished and the water stopped short of the third rail he was seen to stagger, drop the nozzle and fall. It seemed apparent that when the stream came away from the third rail he received a shock.

An investigation revealed the fact that the platform on which he stood was grounded and the voltage in the platform was nearly as high as in the third rail. The latter was 550 volts and that in the platform was 530 or 540. While he was playing on the third rail the voltage that backed up through the stream and which existed in the nozzle was sufficient so that the voltage on either side of his body was approximately the same, *i.e.*, the voltage on the nozzle and platform on which he was standing were the same and he felt no shock. As soon as he stopped playing on the rail, however, the potential of the nozzle ceased to exist and he received a shock from the potential difference between the platform and the ground through his body and the line of hose. (*Electrical World.*)

CASE 6. A loss of life is said to have occurred about 1921 at Newton, Iowa, when the public fire department was fighting a fire in a warehouse. One of the hose streams hit a transformer bank on a pole several feet above the ground and the resulting shock knocked down the men who held the hose, killing one of them. The primary voltage was 2300 volts. The pole was about seven feet from the warehouse. The men were standing against the warehouse wall almost directly under the transformers, and were using a hydrant stream.

CASE 7. In the *Travelers Standard* for October, 1924, was described a fatal accident which occurred when a man threw water from a pail about some electric wires, the current from which had started a fire in a barn. This man was instantly killed and two other persons were shocked into insensibility but were quickly revived by proper treatment. The water from the pail had provided a path for the current to flow through the man's body to the ground, thus causing his death. The other persons who approached his body evidently did not receive the full voltage and therefore escaped death. The fatal outcome in the case of the first man was attributed to the fact that when he threw the water on the wires it undoubtedly left the pail in a solid sheet, which could conduct the current to the pail quite efficiently; and as the pail was made of sheet iron and was firmly grasped in the man's wet hands the conditions for a fatal result were ideally fulfilled.

CASE 8. Three men lost their lives on April 13, 1930, at Ypsilanti, Michigan, when an airplane, as it was about to land at an airport, struck a



P. and A. Photo.

Three men were electrocuted when this airplane fell into high tension wires. One, a passenger, lost his life by direct contact with the charged metal frame of the plane. The others received fatal shocks as a result of using a soda-acid extinguisher on the burning ruins of the plane.

telephone pole. The pilot lost control and the tail of the plane became entangled with the wires of an electric power line—the nose crashing to the ground. In this way the metal parts of the plane completed the circuit between the wires and the earth and became charged to a potential of 4800 volts. The pilot saved his own life by leaping from the plane, but his passenger received a fatal shock. The combustible material in the plane took fire, and a mechanic at the airport directed a stream from a fire extinguisher upon the flames. The liquid from the extinguisher served as a conductor from the electric current, however, and the mechanic was killed instantly. A bystander seized the mechanic's feet, with the intention of rescuing him, and he, too, received a fatal shock. The fire continued to burn until all the flammable material of the plane was consumed, leaving only the skeleton of the ship, as shown in the accompanying illustration.

CASE 9. One fireman was electrocuted and ten others were stunned when a heavily charged wire fell into their midst while they were fighting a fire in a furniture storehouse in Boston, Mass., on September 16, 1930.

While the firemen were directing their streams a live wire crashed from the roof of the building. It is said to have carried 2200 volts. It dropped into a pool of water in which the men were standing. Ten of them received a shock, dropped their lines and ran for safety.

The man who lost his life fell headlong into the pool and in so doing his head struck the wire and he was rendered unconscious. He was dragged from the pool and efforts made to revive him, but with no avail.

In addition to these records of actual experience with high tension lines while engaged in fire fighting, there are numerous instances in the files of the N.F.P.A. Department of Fire Record where the presence of high tension lines has been an indirect factor either in fire fighting or in loss incurred. Such an instance was the fire which occurred on the wharf property of the Nantasket Beach Steamboat Co. at Hull, Mass., on November 28, 1929. (QUARTERLY, Vol. 23, No. 3.)

The fire was discovered by an engineer from one of the boats, who immediately called the other employees. One sounded an alarm from the box on the wharf and another started the electric fire pump which took suction from the harbor. The men on duty ran the hose out to a point behind the fire, which, driven by the wind, had already involved the steamer *Betty Alden.* They planned to keep the fire from spreading back against the wind to the other boats and hold the fire in check until the fire department arrived. This stream was in operation only a few minutes when the current in the 2300-volt primary circuits, which ran to transformers at the shore end of the wharf to feed the pump, was cut off. This was done by employees of the Hull Electric Light Department, acting on standing orders from their manager. The loss of water in this hose line from the private fire pump manned by the company employees was the principal factor in the spread of the fire. In shutting off the current supplying the pump the electrical department protected the firemen from primary wires which ran exposed to the transformer pole on the wharf, but that action resulted in the fire getting beyond control, for it made the position of the employees untenable. It is probable that had the chief of the fire department been consulted this would not have occurred.

While it is usually preferable to make electrical equipment dead before projecting water upon it, there are undoubtedly a great many instances, particularly in fighting ordinary building fires, where it would be a mistake to cut off the electrical service. Such action in many cases would stop fire pumps, lighting systems, elevators, ventilating equipment, etc., the continuous operation of which might be essential to the successful handling of the fire and perhaps to the successful removal of persons from the premises involved.

The Fireproofing of Fabrics.

Report of the Fabrics Co-ordinating Research Committee, British Department of Scientific and Industrial Research, reviewed by A. H. Nuckolls, Chemical Engineer, Underwriters' Laboratories (Member N. F. P. A.).

From an early date attempts have been made to fireproof fabrics, and a great deal of attention has been given to the subject by fire prevention engineers. The recent report of the Fabrics Co-ordinating Research Committee presents a considerable record of experimental work on the fireproofing of fabrics. Following is a brief review of the work accomplished. For detailed accounts of the progress of the research, the reader is referred to the original report.*

Object and Scope of Research.

As stated in the report, the ultimate object of the investigation is to find the most suitable fireproofing processes for use under various conditions.

The meaning of the word "fireproof" as applied to fabric is discussed. The following excerpt from the report is of interest in this connection: "Some writers strongly object to the use of the word in connection with treated fabric, since it is thought that it might convey the impression that the material, when brought into contact with flame, behaved similarly to asbestos, whereas, in fact, it chars and decomposes. The terms 'flame-proof' and 'flame-resistive' have been suggested as more appropriate descriptions of the treatment. These terms are perhaps only a little less inaccurate, since many, at any rate, of the well-known fireproofing processes render the fabric less resistant to flame, *i.e.*, as is shown later, the fabrics so treated are destroyed more readily than untreated fabric when brought into a flame.

"A fireproof fabric may be defined as one which does not propagate flame. Such fabric, when brought into contact with an igniting source, chars, and the gaseous decomposition products may burn on the surface. The flame, however, persists for a short time only and is not propagated beyond the charred area. The damage done thus depends on the size of the igniting flame and is confined to the neighborhood of the flame. The treatment may, therefore, reduce the fire danger enormously, since the fabric does not assist in the spread of flame. In the absence of a simple term which more accurately describes the above properties, the expressions fireproof, fireproofing and fireproofness have been used in this report, since these have received the sanction of long usage." [1]

*May be ordered directly from the Sales Offices of H.M. Stationery Office: London, Adastral House, Kingsway, W. C. 2.

[1] Inasmuch as the treated fabrics char on contact with flame, it would seem that the simple term "flame-proof" would be more appropriate than "fireproof."

The following conclusion is reached as to the method of evaluation of fireproofness: "The minimum quantities of the various substances necessary to prevent flame propagation may, therefore, be taken as indicating *ceteris paribus,* their relative efficiency as fireproofing agents."

The main features of the experimental work include:

(a) The measurement of the rate of flame propagation of fabric treated with various classes of substances.
(b) Detailed observations of the mode of burning of treated fabrics and the character of the ash.
(c) The determination of the minimum amount of various substances required to prevent flame propagation.
(d) A more thorough classification of a number of inorganic substances according to their fireproofing qualities and observations of any relationship which may exist between chemical composition and fireproofing qualities.
(e) The determination of the effect of various substances on the strength of fabric under definite conditions of storage.
(f) The influence of fireproofing agents on the growth of micro-organisms destructive to fabric.[2]
(g) The investigation of the effect of inorganic substances on the behavior of fabric at temperatures approaching the ignition temperature.[3]
(h) The study of the fireproofing action of particular processes.
(i) Other considerations affecting the choice of a fireproofing process.

With respect to item (i), for some purposes it is desirable that the treated material retain its softness and flexibility. Substances which render the material hygroscopic are objectionable in some cases.

Cotton fabric has been used throughout the test. It is considered that the fire hazard of cotton is a drawback to its general use. It is assumed that "results obtained with cotton may be expected to apply to other materials composed of vegetable fibers such as linen and hemp, and to a limited extent to woolen and silk fabrics."

Literature.

A comprehensive survey of the literature on the subject, together with an interesting historical treatment is given. It is mentioned that Æneas, in the fourth century B.C., recommended the use of vinegar to impregnate wood. It is recorded that the wooden storming towers at the siege of Piræus, B.C. 83, were protected from fire by a solution of alum. There are published records on the fireproofing of fabric of more recent date. In 1638 Sabattini published in Italy a book on the danger from fires in theatres, recommending that clay and plaster of Paris be mixed with paint for use on the canvas. Ferrous sulphate and alum was recommended by Fagot in 1740. Ammonium phos-

[2] Apparently much work as yet remains to be done on this phase of the subject. See Appendix V of the report for further information.

[3] This is a technical phase of the work. Those interested should refer to the original report.

phate for fireproofing theatre curtains was recommended by Arfird in 1786.

It is stated that the first systematic investigation on fireproofing was apparently carried out by Gay Lussac in 1820 at the instigation of Louis XVIII of France, who concluded "that the most effective salts were those which had a low melting point and covered the surface of the fabric with a glassy layer or which gave off non-flammable vapors on heating." Most of the literature of more recent date deals with the description of particular processes.

Methods of Fireproofing.

A list of available fireproofing processes, together with a discussion of them, is given. It is stated that there are two main types of fireproofing processes: one which deposits salts on the fabric that are readily removable with water, and the so-called "permanent" process in which an insoluble compound is precipitated on the fabric. It is concluded that "while for some purposes the use of soluble salts is admissible, such substances are not very suitable for materials likely to get wet or for garments which require frequent washing."

The usual method of treatment in the case of "permanent" fireproofers is to treat the fabric with a soluble salt, which on immersion in a second solution is precipitated on the fibers. "In the process known as 'Non-Flam,' first put forward by Versmann and Oppenheim in 1859 and developed by Perkin, the fabric is impregnated with sodium stannate and after drying treated with ammonium sulphate, thus causing the precipitation of stannic oxide on the fiber.

"Some new light has been thrown on the mechanism of fireproofing action, although it cannot be claimed that a complete explanation can yet be given. It has been assumed that the action could be explained in one or other of the following ways: (1) the fireproofing agent fuses below the ignition temperature of fabric and coats it with a layer more or less impermeable to air; (2) the fireproofing agent evolves non-flammable gases which extinguish flame; (3) the heat of the flame is taken up by some change in the fireproofing agent which involves absorption of heat; (4) the heat of the flame is dissipated by conduction. The investigations show that none of these explanations fully accounts for the observed facts. It seems clear that chemical action between the impregnating substance and fabric must play an important part."

Method of Test.

Several experiments were conducted to determine a suitable method of test. "The vertical strip method was found to provide not only a more severe test for fireproofness, but also to give more concordant results, and this method has, therefore, been adopted."

Experiments were conducted to determine the best size of a strip to use for the test. It was found that "for strips from $\frac{1}{2}$ inch to 6 inches wide, the rate of flame propagation increased with the width of the strip up to about

3 inches and then became practically constant. Wide strips had, however, the drawback that simultaneous ignition along the whole width was not easy, and burning proceeded at varying rates at different points along the width of the strip. Consequently, it was difficult to obtain reasonable concordant results with strips more than 1 inch wide.[4]

Summary of Results with Various Classes of Inorganic Compounds.

A very complete and valuable summary of test, covering about 65 pages, is given. The summary gives the results of flame propagation measurements and a detailed discussion of the behavior of the treated samples. The following compounds are included: Boric acid and borates, phosphoric acid and phosphates, sulphates, halides, oxides and hydroxides, nitrates, carbonates, tungstates, silicates, stannates, and molybdates.

Inasmuch as the majority of fireproofing processes advocated are mixtures of substances, a number of binary mixtures are included in this study, as follows:

Ammonium phosphate and ammonium bromide.
Sodium phosphate (ortho) and phosphoric acid.
Disodium silicate and borax.
Sodium silicate and borax.
Boric acid and borax.

The following excerpts from the results are of interest:

"A noteworthy feature of fabric treated with phosphoric acid was that when 1 to 5 per cent was present the flame appeared to be propagated at a more rapid rate than with untreated fabric. With larger amounts the rate became gradually slower, until with about 10 per cent flame ceased to be propagated. With ammonium phosphate a similar behavior was observed.

"Sodium hydrogen phosphate adhered very badly to the fabric, whereas adhesion, in the case of the two foregoing salts, was good. With 35 per cent on the fabric, flame propagation was still rapid.

"Sodium sulphate adhered badly to the fabric. Even when 75 per cent was present, flame was propagated at a rapid rate.

"Alum was one of the first substances to be used as a fireproofing agent. It was found, however, to have relatively little effect on the inflammability of fabric. When 140 per cent was present flame was still propagated.

"Hydrated stannic oxide has the important property of adhering tenaciously to the fabric. When about 40 per cent was present, flame ceased to be propagated. The fabric, however, continued to glow when the igniting flame

[4] In experiments on flame-proof fabrics at the Underwriters' Laboratories, the results indicated the desirability of using vertical strips inside of an enclosure. The apparatus finally designed for this purpose is described in "Laboratories' Data," Vol. IX, No. 5. It is interesting to note that in the Laboratories' tests it was found in some cases that a vertical strip that would not propagate flame when suspended alone would propagate flame readily if suspended with a number of other vertical strips with air space between. This method of test has the justification that it approaches closely conditions often met with in practice.

was removed, and the whole of the strip was destroyed by flameless combustion at the rate of about .01 inch per second. In a rapid current of air the action became so vigorous that the fabric occasionally burst into flame.

"Although hydrated stannic oxide is usually regarded as a 'permanent' fireproofer, fabric with 40 per cent of this substance was found to burn readily after a short exposure to rain. In preparing the specimens, it was observed that the amount required to prevent flame propagation depended on the thoroughness of the washing, carried out after precipitation. When the specimens were washed in cold water for one hour, 25 per cent prevented flame propagation, but when hot water was used, 40 per cent was necessary. Specimens prepared in the latter way burned readily after boiling in water for a short time. This unexpected behavior is being further investigated.

"Hydrated silica and alumina had little effect on the rate of flame propagation, even when very large amounts were precipitated on the fabric.

"A number of the substances evolve non-flammable gases, steam, ammonia or carbon dioxide. Sodium sulphate contains 55.9 per cent of its weight of water, but is little better than sodium chloride in reducing the rate of flame propagation. The simple ammonium salts of inorganic acids are good fireproofers, but here the acid may play the dominant part, thus phosphoric acid is more effective than ammonium phosphate. Substances such as ammonium alum and magnesium ammonium phosphate are not good fireproofers, but in some cases the evolution of ammonia may be responsible for the reduction in the rate of flame propagation; thus microcosmic salt is more effective than sodium dihydrogen phosphate and ammonium borate than boric acid. Sodium bicarbonate is less efficient than sodium carbonate, and this is very slightly inferior to caustic soda as a fireproofer. Calcium carbonate is not a good fireproofer, neither is guanidine carbonate or ammonium carbonate.

"Sodium tungstate possesses noteworthy features, since 9 per cent was found to prevent flame propagation, and although the charring temperature of the fabric was slightly lowered, the loss in strength, on heating in air at 200° C., was reduced. This protection may be due to the exclusion of oxygen from the fabric, since it has been shown that if oxygen is excluded deterioration and color change are greatly reduced. It may be concluded that, in general, substances which are efficient fireproofers increase the destructive action of heat on cellulose. The temperature at which the effect becomes appreciable varies considerably. In some cases almost complete destruction takes place at quite low temperatures. With sodium tungstate, however, the effect is not apparent up to 200° C. Those substances which destroy fabric at low temperatures have a tendency to prevent glowing of the charred fabric and consumption of unchanged fabric by flameless combustion. Substances such as sodium tungstate and stannic oxide, which apparently only react with fabric at high temperatures, tend to promote this action, and in the case of stannic

TABLE 1.

	Class 1	Class 2	Class 3
Borates	Ammonium borate.. 24 Borax ..... 60 Borax + boric acid 1:1 10		Aluminium borate.... 59
Phosphates	Ammonium phosphate ..... 12 Guanidine phosphate 19	Sodium phosphate... 20 (ortho)	Magnesium ammonium phosphate ..... 125 Sodium dihydrogen phosphate ..... 54 Sodium hydrogen phosphate ..... 145 Microcosmic salt..... 70
Sulphates	Ammonium sulphate 8		Sodium sulphate..... 70 Potassium alum..... 140 Barium sulphate..... 100 Ammonium alum..... 80
Halides	Ammonium bromide 7 Ammonium chloride 38 Ammonium iodide... 14 Calcium chloride.... 14 Magnesium chloride 16 Zinc chloride..... 12		Sodium chloride..... 114 Calcium fluoride..... 50
Oxides and Hydroxides	Sodium hydroxides.. 10 Sulphuric acid Phosphoric acid..... 10	Ferric hydroxide.... 25 Stannic oxide hydrated ..... 40 Lead peroxide..... 60 Arsenic acid..... 20 Chromic acid Chromic hydroxide.. 91 Titanic hydroxide... 40	Silica hydrated..... 100 Aluminium hydroxide 70 Cerium hydroxide.... 69 Boric acid..... 90 Bismuth trioxide hydrated 40
Nitrates		Potassium nitrate... 13	Lead nitrate..... 60 Ammonium nitrate... 100
Carbonates	Sodium carbonate... 12 Sodium bicarbonate. 23		Barium carbonate.... 91 Guanidine carbonate. 50
Tungstates	Sodium tungstate... 9		Zinc tungstate..... 54 Calcium tungstate.... 96
Silicates	Sodium silicate..... 20		Magnesium silicate.. 116 Tin phospho silicate. 64 Aluminium silicate.. 100
Stannates	Sodium stannate.... 18	Zinc stannate..... 40	
Molybdates	Ammonium molybdate ..... 7 Sodium molybdate... 6		
Miscellaneous	Sodium aluminate... 19 Antimony oxychloride ..... 30 Sodium arsenate.... 33	Lead chromate..... 37 Ferric chromate..... 24 Sodium selenite..... 36 Selenium ..... 50 Potassium permanganate ..... 22 Potassium thiocyanate 25	Aluminium acetate base ..... 140 Barium oxalate..... 78 Sulphur 50

oxide to such an extent that the whole of the unchanged fabric is vigorously destroyed by flameless combustion."

Classification of Fireproofing Agents.

A classification of inorganic substances according to their fireproofing qualities is given. The substances included in this study are divided by the committee into three classes according to the degree of their flame proofing properties.

Class 1 includes substances which can be readily applied in amounts that will prevent flame propagation by the fabric. "Such fabric, when brought into contact with an igniting source, is charred, and the gaseous decomposition products burn on the surface. The flame, however, persists for a short time only and is not propagated beyond the charred area. The charred mass left when the flame dies out may be observed to glow at the edges, and the glow may travel over the greater part of the charred region. It generally ceases, however, when the uncharred fabric is reached. In some cases, notably with ammonium phosphate, no flame is visible when the igniting source is removed and the charred fabric does not glow."

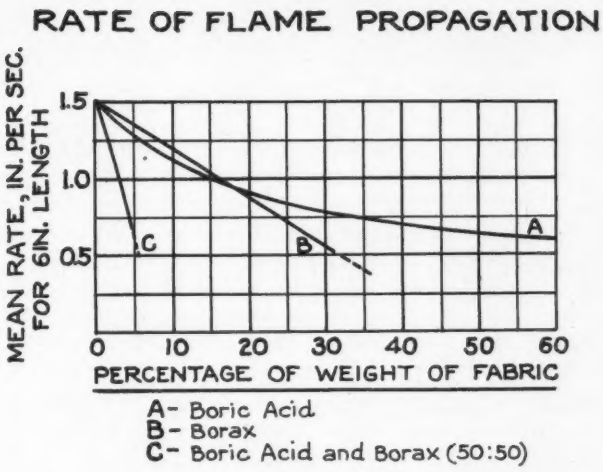
Class 2 includes substances that also prevent flame propagation by fabric but do not prevent glowing of the cleaned fabric or propagation of flameless combustion by fabric.

Class 3 includes substances that do not prevent flame propagation by fabrics, but retard the rate of flame propagation when present in the largest practicable amounts.

The committee regards the substances given in Classes 1 and 2 in the accompanying table as "efficient fireproofing agents in the generally accepted use of the term." The figures accompanying the names of the substances in Classes 1 and 2 "are the approximate minimum quantities, expressed as percentages of the weight of the fabric, required to prevent flame propagation." The figures in Class 3 represent the maximum quantities of the substances which can be readily applied to fabric.

Boric Acid and Borax Mixture.

It is further concluded that a "mixture of 30 per cent boric acid and 70 per cent borax, when applied to light cotton fabric, prevents the propagation of flame when present to the extent of about 6 per cent of the weight of the fabric. The proofed fabric retains its softness and flexibility. It does not become dusty or feel damp. Specimens stored for 100 days at ordinary temperature retained their strength unimpaired. When stored at 40° C. the loss in strength, after 365 days, was 7 per cent, and specimens exposed under glass to direct sunlight for 100 days lost 27 per cent of their strength, the untreated fabric losing 20 per cent during the same period. The material is non-poisonous, and has been shown not to promote the growth of destructive



micro-organisms in tests, conducted under the supervision of Dr. A. C. Thaysen, at the Royal Naval Cordite Factory, Holton Heath. It is cheap and its application to fabric is simple. It may, therefore, be regarded as one of the most suitable 'soluble'[5] fireproofing agents for cotton fabric."

Readers will be interested in the curve given showing the results of tests with boric acid, borax, and boric acid and borax.

Further experimental work by the Research Committee is in progress, attention being given to the possibility of developing a "permanent" treatment.

[5] Attention of the reader is called to the fact that the boric acid mixture is soluble in water and, therefore, the cotton fabric will lose its flameproofing qualities on repeated exposure to the weather and washing.

Non-Combustible Scaffolding.

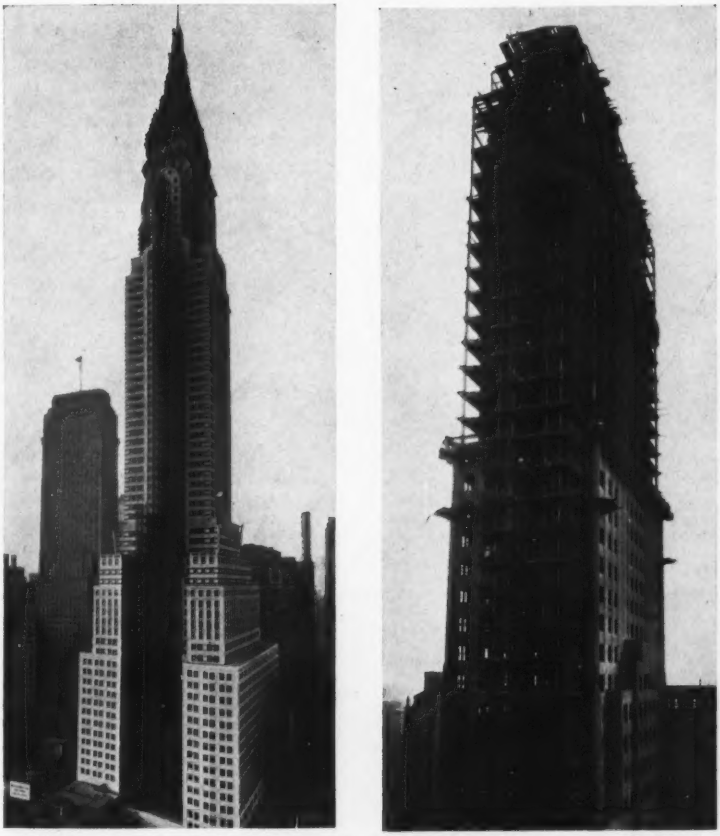
Building construction is an industry which by its very nature is difficult to control in respect to fire protection. The temporary nature of the business tends to a certain amount of laxness in such fundamentals as good housekeeping and the installation of adequate fire fighting appliances. Good housekeeping is essential on account of the general use of combustible packing materials. The presence of salamanders, acetylene torches, as well as the hazard of smoking renders the installation of fire pails, extinguishers and watchman service imperative. Since the standpipe or sprinkler system is rarely available for maximum service during the construction period, it is of prime importance to be properly equipped with fire fighting appliances which may turn out to be the only means of stopping a fire.

In addition to poor housekeeping and lack of adequate fire fighting equipment, another serious hazard is often encountered, namely, temporary wooden scaffolding. Under this heading are included interior and exterior scaffolding, material hoist towers, sidewalk bridges, etc.

The danger of fire in temporary scaffolds can be minimized by the use of metal scaffolding, several types of which have been introduced in this country during recent years. The designs were originally patterned after the foreign, but were modified when it was found after long trial and experiment that certain changes of a mechanical nature were needed to make the scaffolding suitable for domestic practice. This modern scaffolding is so designed as to be adaptable for usage under any conditions, while at the same time it meets all the requirements formerly filled by wooden scaffolding. It is made of a framework of interlocking tubular steel members which are fastened together by specially designed coupling devices. Scaffolds of this type are used indoors or outdoors to any height, and are employed by all trades. In connection with this scaffolding it is customary to use decking of planks which have been made flame-resisting by chemical treatment.

Temporary exterior material elevator hoists, which were formerly all constructed of wood, are now also being built of steel in all the larger cities, thereby eliminating another source of danger. It is now also becoming the accepted practice to use steel barricades of expanded metal panels on a framework of steel for enclosing hoist shaftway openings in the floors of the building.

Steel scaffolding is to be recommended not only because it is non-combustible, but also because it presents a much neater and more trim appearance than the old-fashioned wooden scaffold, not to mention greater ease of erection, decreased wind resistance, smaller storage space required on jobs, less

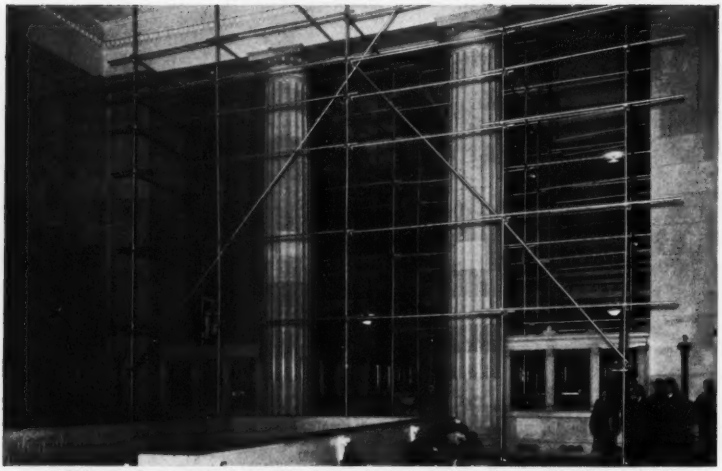


Modern practice in the construction of New York skyscrapers calls for the use of non-combustible scaffolding, as these pictures show.

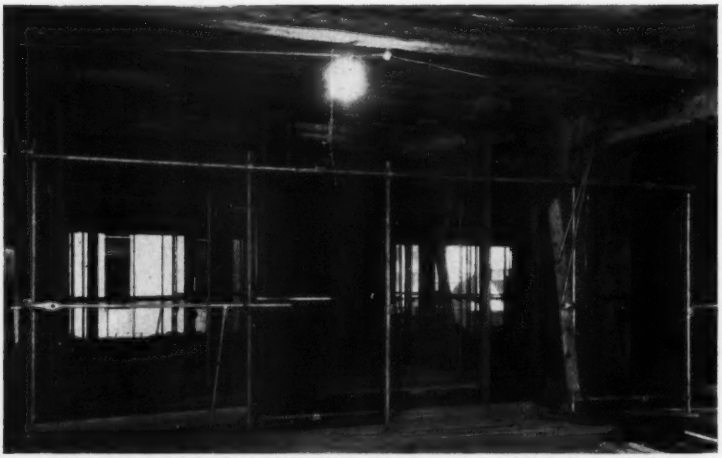
difficulty in trucking and handling, as the sections are not unduly long, etc.

Another evidence of the tendency to supersede the use of combustible materials in temporary structures is the introduction of steel sidewalk bridges, which are now widely used in most cities. These are for the protection of pedestrians and consist of heavy steel uprights supporting a gridiron of I-beams covered with a suitable deck.

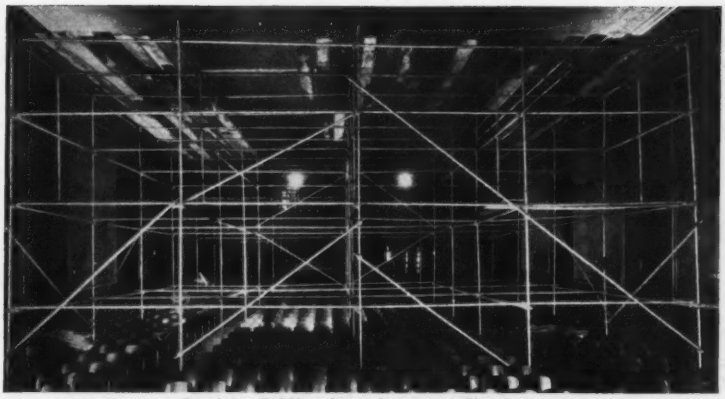
The Bureau of Surveys of the New York Board of Fire Underwriters, in their report on the fire which occurred in the Riverside Church in New York nearly two years ago, emphasizes the importance of using only non-combustible scaffolding material. The fire in question was an excellent example of



A Chicago bank interior. The use of non-combustible scaffolding eliminates fuel for a potential fire and minimizes obstructions to the regular operation of the bank.



Typical interior view of a New York bank under construction on the most costly site in the world. Note steel supports and enclosure for hoistways. Owing to the amount of the investment in the site and building construction, daily interest charges are a heavy item, calling for every precaution to prevent fire damage that might delay the occupancy of the building.



Steel scaffolding in a theatre auditorium.

the loss of property which a scaffold can cause. The following are excerpts from their report:

The extreme hazard of the use of large quantities of flammable material for scaffolding or similar structures has again been strikingly demonstrated to the vexation of underwriters, who have recognized its potential danger and advocated its elimination or reduction.

The fires that damaged the Sherry-Netherlands Hotel, the new Fifth Avenue Æolian Building, and the Pennsylvania Hotel occurred in such temporary scaffolding or sidewalk bridging and prominently displayed the danger in the use of such type of material.

Aside from the insurance viewpoint and the monetary loss involved, the use of such combustible material in large quantities is a decided menace to the city. It was necessary to sound a total of five alarms to bring sufficient apparatus and fire department personnel to extinguish this fire and protect surrounding property. Even with the concentration of such a fire fighting force, the fire was extinguished with difficulty. Had the church been located in a more thickly builded section of the city the result might have been decidedly more disastrous. Besides this, the calling of such a large number of pieces of apparatus and firemen may weaken the fire protection to other parts of the city to a dangerous degree and result in the start of a conflagration. It should be borne in mind that the cost of operating such a quantity falls directly on the taxpayer.

That the building fraternity has not taken greater steps toward the elimination of this hazard is regrettable, but it may be possible that legislation of a mandatory nature is needed.

The hazard of flammable scaffolding seems to have been eliminated in the new scaffolding. The scaffolding now consists of various sized metal piping, fastened together by special clamps for all the supporting and cross members, while the platforms themselves consist of heavy wood planking treated to make them flame-resisting.

The new scaffolding appears to be a solution of the problem of the fire hazard of combustible scaffolding by the use of metal supporting members and flameproofed wood platforms.

While it will be noted that this report deplores the lack of foresight on the part of builders generally, it must be conceded that considerable progress has been made since its issue. The more progressive builders have profited by

the lesson and are resorting to noncombustible scaffolding. It may be seen on the photographs that most of the more prominent recent operations have used this modern scaffolding. To judge from the recent trend, the day is probably not very far off when a fire-resistive building will be fire-resistive not only after completion but also during its erection.

Fire Record of Buildings Under Construction.

The files of the Department of Fire Record of the National Fire Protection Association contain reports on eighty-five fires occurring in buildings under construction. These fires have, for the most part, occurred during the past fifteen years. This record is incomplete in that it does not include many of the small fires which are occurring daily in construction operations, involving little or no loss.

A fairly comprehensive record of fires and losses in buildings under construction was included in the report of the Committee on Construction Operations presented at the 1930 Annual Meeting of the N.F.P.A. (Proceedings, 1930, page 37). This record, while including some of the fires in the N.F.P.A. record files, also contained a considerable number obtained from other sources by the committee. Data relative to these fires have been incorporated with the fires recorded by the Department of Fire Record in the following tables.

The amount of loss involved in fires in buildings under construction is given in the table below.

Analysis of Loss.	No. Fires
Slight or less than $1000	62
$1000-$9999	19
$10,000-$24,999	10
$25,000-$100,000	15
Over $100,000	15
Considerable or large—no specific data	13
Unknown	37
Total fires	171

There were eight fires where a loss of life occurred. The table which follows summarizes the causes of the loss of life rather than the cause of the fire.

Causes of Loss of Life.	No. Deaths	No. Fires
Flash fire (use of flammable liquids or compounds)	4	3
Rapid spread of fire under pier trapped workers on raft	4	1
Clothing ignited by explosion of oil switch	3	1
Inadequate exits in bunk house	2	1
Suffocation while asleep in tool shed	1	1
Contact with high tension wires on scaffolding	1	1
Total loss of life	15	8

The causes of fires in buildings under construction are shown by the following table. Of these fires, 85 were taken from N.F.P.A. fire records and 86 from the tabulations of the committee.

Causes of Fires in Buildings Under Construction.

Salamander fires		39
Tarpaulin ignited by salamander	11	
Salamander	27	
Gasoline for motor of concrete mixer ignited by salamander	1	
Riveting and welding fires		32
Sparks from acetylene torch	17	
Hot rivet ignited planking	2	
Canvas ignited by sparks from riveting or hot rivet	2	
Acetylene gas cylinder ignited	2	
Hot rivet ignited planking or canvas	9	
Flammable liquids and materials		17
Flammable floor compound ignited by careless smoker	2	
Gasoline lantern	1	
Gasoline torch explosion	1	
Gasoline vapors ignited by blow torch	1	
Drying composition flooring with blow torch	1	
Asphaltum floor compound ignited	1	
Tar kettle boiled over	7	
Paint spray ignited by open fire from heater	1	
Kerosene used for keeping new concrete warm ignited	1	
Kerosene blow torch	1	
Smoking—matches		14
Electrical fires		9
Trouble with electric feeders for elevator machinery	1	
Defective wiring	4	
High tension wire fell across building	1	
Short circuit	2	
Oil switch exploded in transformer room	1	
Miscellaneous		14
Roofer's furnace	1	
Heater	2	
Wind overturned bucket of coals from forge	1	
Small workers' stove overturned	1	
Sparks from locomotive	1	
Burning rubbish	1	
Sundry causes	5	
Sparks from forge	1	
Annealing furnace	1	
Spontaneous ignition of oily waste and painters' material		6
Lightning		1
Incendiary		11
Total known causes		143
Unknown		28
Total fires		171

Further to amplify the N.F.P.A. fire record and to indicate the relative frequency of fire in buildings under construction, two tables have been prepared covering such fires in the State of Massachusetts for the period 1919 to 1928 inclusive.

Fire Record—Buildings Under Construction.
State of Massachusetts.
Losses, 1919-1928 Inclusive.

Year	No. Fires	Loss—Buildings	Loss—Contents	Total Loss
1919	11	$6,923	$1,697	$8,620
1920	14	35,764	130	35,894
1921	12	12,520	3,947	16,467
1922	24	26,757	637	27,394
1923	23	45,197	3,008	48,205
1924	29	84,987	2,465	87,452
1925	26	63,453	7,027	70,480
1926	23	219,561	4,110	223,671
1927	31	95,074	1,958	97,032
1928	21	57,261	20,607	77,868
Total—10 years	214	$647,497	$45,586	$693,083

Fire Record—Buildings Under Construction.
State of Massachusetts.
Causes, 1919-1928 Inclusive.

Cause	No. Fires
Smoking—matches	26
Spontaneous ignition	20
Overheated or defective heating equipment	18
Combustible material ignited by lighting or heating equipment	13
Sparks from forge, furnace or stove	10
Mechanic's torch	10
Malicious mischief	5
Bonfires	4
Electric Causes	4
Flammable liquids, ignition of	4
Children and matches	3
Defective oil burner	2
Miscellaneous known causes	11
Incendiary	4
Unknown—suspicious	10
Unknown	11
Not stated (1921-22-23 causes not classified)	59
Total	214

Typical Large Loss Fires in Buildings Under Construction.

JANUARY 18, 1924. APARTMENT HOUSE, NEW YORK, N. Y. A six-story and basement ordinary brick apartment house was badly damaged by a fire which apparently originated from a coke-fired salamander. Due to the open unfinished condition of the building the fire spread rapidly through the rear section of the structure.

It is stated that the man in charge of the salamanders placed fuel on them at approximately 2:30 A.M. and then went to a similar building adjoining to care for other salamanders there. About twenty-five minutes later a taxi driver noticed smoke coming out of the windows and the alarm was sounded.

The McDougall Terminal Warehouse Fire at Duluth. This concrete building under construction contained a large amount of wooden forms which made excellent fuel for the flames. A salamander is thought to have been the cause of the fire.

The damage consisted of the destruction of the entire rear half of the building, together with the roof and top floor of the front section. The total loss was $75,000. (H-26528.)

JULY 22, 1925. APARTMENT HOUSE, DETROIT, MICH. Fire starting in a three-story apartment building under construction destroyed the building itself and badly damaged two adjoining apartment houses. This fire was of interest because it showed how, under several adverse circumstances, a fire initially unimportant can become a serious one. The loss was estimated at $250,000.

At the time of the fire the construction work was complete except for plaster, interior trim and the installation of windows. Carpenters and other workers were at work when the fire started. A structural iron worker was using an acetylene torch on the second floor of the building. His helper stood by with a pail of water to extinguish any incipient fires which sparks of molten metal from the torch might cause. It seems evident, however, that some of the sparks fell unnoticed through the flooring to the floor below. About six minutes after the workmen had finished their cutting operations, and as they were picking up their tools preparing to leave, they noticed smoke coming up from the first floor. Running to the first floor they saw that the fire was beyond their control, and they returned to the second floor in order to remove the acetylene tank. They were prevented from doing this, however, by the smoke and fire.

Several persons attempted to call the fire department on the telephone, but the spreading fire had severed the telephone cable in the rear of the building. After considerable time had been lost someone pulled the alarm box and

the response of the fire department was prompt. They lost no time in getting to work and shortly had four lines of hose laid and playing on the fire. When they arrived the apartment itself was a mass of flames and the buildings across the street were already burning.

Additional alarms were sounded, whereupon a further handicap developed in the form of traffic congestion due to automobiles and pedestrians near the scene of the fire. The firemen gradually surrounded the burning buildings and by deluging them with water they limited the loss to the total destruction of the building in which the fire originated and some frame garages. Severe damage resulted to two adjoining apartment buildings and two dwellings. It is said that at least twenty-five wooden shingle roof fires, caused by flying brands, broke out in different locations within a few blocks of the fire. (H-22369.)

DECEMBER 24, 1925. CONVENT, HUDSON, N. H. A reinforced concrete school building was in process of construction. The pouring of the fourth floor was being hastened so that it might be completed before work was suspended for the holiday. At noon a large section of freshly poured concrete was in place, and to prevent this from freezing a number of salamanders were in use, the heat from which was retained by canvas tarpaulins hung at the walls.

Shortly after noon a workman, who was eating his noon meal at a near-by farm house, glanced toward the building and saw one end of it a mass of flames. Three other workmen who had remained in the building did not become aware of the fire until it was well advanced, and they had considerable difficulty in escaping. In spite of the absence of wind and the wet condition of the woodwork as a result of several days' rain, the fire spread very rapidly.

No water barrels or chemical extinguishers had been provided. Furthermore, there was no public water system or other adequate water supply available. The pumper of the Hudson fire department, after much difficulty, obtained a suction supply from a near-by swamp and was able to furnish one stream, but this was not until it was too late to be of use.

Raging unchecked, the fire consumed the wooden forms throughout the building and jumped to several equipment and supply sheds, which were totally destroyed. When the wooden forms burned away from the concrete floor which had been poured that morning, it collapsed, falling to the floor below. Part of the concrete poured the previous day also fell, and the remainder was badly disrupted.

Smoking and incendiary origin were suggested as the cause of the fire, but considering the general use of salamanders it seems logical to suppose that they were responsible. The loss was estimated at $225,000. (H-22909.)

MARCH 14, 1926. AUTOMOBILE FACTORY, DETROIT, MICH. Fire was discovered by two mill watchmen at 12:45 P.M. on Sunday, in a new four-story

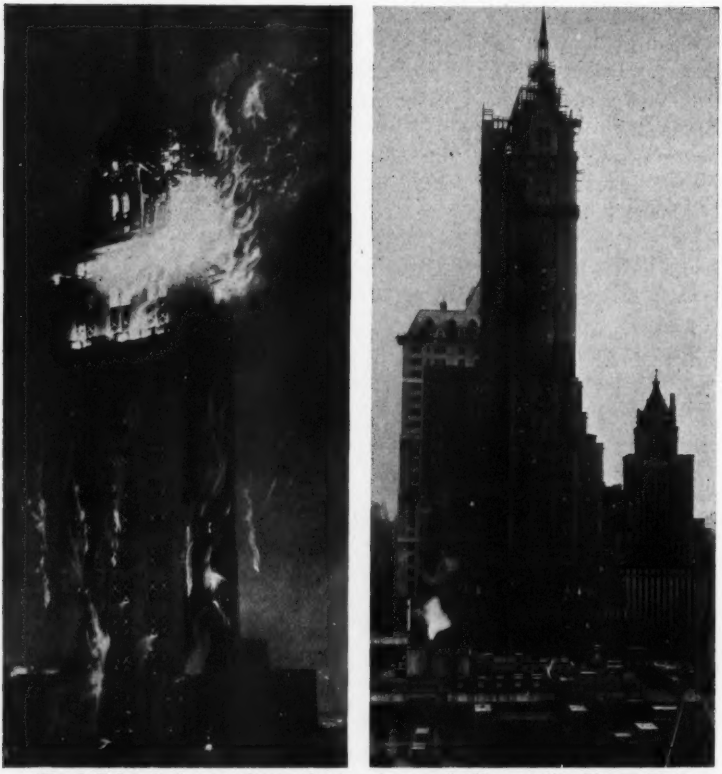
reinforced concrete addition under construction. About 112 feet of the third floor slab at the west end had been poured and coke-fired salamanders were in use to prevent freezing. Tarpaulins were used to retain the heat in the second and third floors of the west and south sides. A fairly strong wind was blowing and it is thought that the tarpaulins caught fire from the salamanders. The fire was fought by the mill and city fire departments, using a dozen hose streams. There were no sprinklers where the fire started, but the fire spread to sprinklered sections, where approximately 500 heads opened. The fire was extinguished after more than two hours' work. The loss was over $75,000. (S-42091.)

APRIL 13, 1927. HOTEL, NEW YORK, N. Y. The building was of modern fire-resistive construction and was practically finished except for the top portion of the tower, where there was considerable frame scaffolding. Two frame hoists extended from the first floor to the cupola on the outside of the building. The structure was some 12,000 square feet in area up to the 17th floor. From the 17th to the 23rd floor set-backs reduced the area to 3000 sq. ft., and a tower of this area extended to a point 38 stories above the street, with the cupola approximately three stories higher.

The only fire protection was an uncompleted standpipe installation. At the time of the fire tanks had been installed in the tower and on the 23rd and 12th floors. Two 8-inch standpipes were in position, one of them extending to the tower. This latter standpipe to the tower had not been connected to the tank and was uncapped. Also a cross connection between the two standpipes on the 22nd floor was uncompleted, and only one of the four siamese connections at the street was finished, although all check valves were in.

No definite cause can be assigned to the fire, although it may have started from a tinsmith's charcoal furnace which had been in use in the vicinity during the day. Just about dark it was noted from the street that the scaffolding was ablaze at about the 38th floor and a patrolman turned in an alarm to the fire department.

Fire department attempts to send water to the location of the fire were fruitless. Connections were first made to standpipe outlets on the lower floors, but the uncompleted cross connection on the 22nd floor prevented water from going higher. The fire department reports that its men finally inserted a piece of pipe at that point and closed up the cross connection, but not very satisfactorily, for they were unable to obtain or maintain the pressure required. It also appears likely that water escaped from the system through faulty seating of a check valve in one of the siamese connections. The fire department burst many lengths of hose connecting their pumpers with the standpipes. Some of these breaks were due to burns on the hose from falling timbers, but most of them were due to the extremely high pressure necssary to send the water to the top of the building.



The left-hand picture shows the burning scaffolding of the Sherry-Netherlands Hotel with the blaze at its height. Burning beams and embers showered the surrounding property during the fire, doing considerable incidental damage. At the right is a view taken the morning after.

Unimpeded, the fire spread rapidly throughout all the scaffolding on the tower and soon involved the two frame hoists on the north side of the tower. The damage was chiefly to the exterior of the building and to the elevator machinery at the top of the tower. Steel H-columns at the top of the tower which had not been protected with "fireproofing" material buckled, while the protected ones were not damaged. This emphasizes the need of fireproofing all supporting steel members as promptly as possible. Falling and burning timbers showered the surrounding buildings during the fire, doing considerable incidental damage. The loss was $516,000. (H-24500.)

MARCH 25, 1928. APARTMENT HOUSE, NEW YORK, N. Y. A mysterious fire completely destroyed the interior of an unfinished six-story brick, 85-family apartment house located only a few blocks from the scene of a similar

fire which had destroyed another large apartment building about a month before. The building was 80% finished. The lathing had just been completed and only the wood trim, plaster, paint and fixtures remained to be put in. As there were no salamanders or other hazards such as stoves or heaters, no electricity and no steam, the origin of the blaze is unaccountable unless it was of incendiary origin.

The fire was discovered at 4:27 Sunday morning by a woman residing in an adjoining apartment building. The fire had extended over considerable area of the third, fourth and fifth floors when discovered. Workmen had left the building Saturday afternoon. The building owner employed an Italian about 65 years of age, who spoke no English, as watchman. The watchman was in his shanty on the sidewalk when the fire department arrived and admitted that he had not been out of his shanty for an hour.

Firemen summoned on five alarms confined the fire to the building in which it originated. The loss was $208,306. (H-25784.)

SEPTEMBER 6, 1928. PIER, SAN FRANCISCO, CALIF. Four lives were lost and fourteen persons were injured when a pier being built of concrete and wood construction at a cost of more than $1,000,000 was swept by a fire doing $64,296 damage. The pier was intended for general dockage, having railroad facilities and a new ferry slip.

To prevent salt water from seeping through the outer surfaces of the concrete piers and attacking the steel reinforcing bars, the exposed surfaces were being coated with a waterproofing solution. The timbers and piling of the wooden sections of the pier are creosoted before delivery. In the course of driving the piles and placing the wood members in position, accidental abrasions occur. To remedy this and the above mentioned condition a coating of tar was applied by means of a pressure spray gun at a temperature of 400 degrees F. To make this hot tar solution adhere to the wet piling and other wet surfaces they first had to be dried. The drying process was accomplished by use of a kerosene blow-torch supplied from a pressure tank on the top side of the deck, and the work generally was carried on when the tide was low so as to dry and coat as much of the piles as possible.

While drying the piles with the torch it went out for some unknown reason, and in adjusting it so that it would again light properly, considerable oil was allowed to flow over the deck of the raft on which the workmen stood. Relighting the torch, this surplus oil became ignited. Attempts were made to extinguish the fire with sacks, but the heat became so intense that it drove the men from the raft and ignited the piling and surrounding timbers, which quickly spread, aided by the newly applied tar solution.

Only one of the four men working on the raft escaped. Due to the fire floating on the surface they were compelled to swim under the water. Three of the men were said to have worn hip boots and were drowned. The man

Brown Bros.

The Riverside Church, New York City, damaged to the extent of more than a million dollars by a fire, thought to have been due to defective temporary electrical wiring, which swept through the combustible scaffolding.

who escaped was a strong swimmer and, not encumbered by heavy boots, got beyond the fire. A barge tied alongside of the pier took fire, which spread so rapidly that the watchman, who was asleep in his cabin, was burned to death.

Approximately 700 feet of the creosoted wood timbers and piles on the east side of the wharf were destroyed, and the fire also damaged a pile driver, crane, lighter, and a gasoline launch. (H-26744.)

DECEMBER 21, 1928. CHURCH, NEW YORK, N. Y. The hazard in the use of large quantities of flammable material for scaffolding was again demonstrated by a fire of undetermined origin which spread rapidly through scaffold-

ing and did damage estimated at $1,500,000 to a large stone church building. The first notification of the fire came from a workman who had heard the crackling of the fire, while tending the boilers in the sub-basement. He notified the watchman, who sounded an alarm from a box inside the church entrance. When the fire department arrived the flames had already mounted the 387-foot tower structure and the entire interior of the church was a mass of flame.

Although the cause of this fire has been impossible of determination, it is practically certain that it originated well up on the working platform toward the north end of the nave. At this location there was apparently nothing that could have caused the fire, except possibly the temporary electrical wiring. The fire obliterated all evidence of its inception. A stiff wind from the northwest carried the flame from the north to the south end of the structure, where the partly enclosed tower acted as a flue which received its draft from the window openings in the nave. (H-27628.)

JANUARY 24, 1929. APARTMENT HOUSE, STATEN ISLAND, N. Y. A six-story apartment house, one of a group of four which were about 66 per cent completed, was destroyed by a fire which raced through the bare lath and studding. The building had not been plastered, due to a recent plasterers' strike. A borough call was sounded to bring apparatus from Manhattan to assist the Staten Island firemen. The cause of the fire is unknown, but incendiarism is suspected. The loss was approximately $250,000. (H-27756.)

JUNE 25, 1929. APARTMENT HOUSE, NEW YORK, N. Y. The building in which the fire occurred consisted of five equal sections, each ten stories in height. The four lower floors were of fire-resistive construction, while the upper floors were of ordinary brick joisted construction. Owing to the topography of the land, with pronounced differences in grades (the structures were built against a hillside), the first three floors and basement extended back only approximately half the depth of the upper seven floors. Rough plastering had been applied in but one of the five sections.

The fire was discovered shortly before 11 P.M. by an occupant of an adjacent building. When discovered there were two separate fires burning in the rear of the north wing. A delayed alarm, coupled with the incomplete condition of the building and the exposed wooden lathing, allowed the fire to spread rapidly through the building. When the fire department arrived the interior of the building was a roaring furnace. The department had difficulty in getting hose streams to the rear sections because of their inaccessibility. All but the southernmost section of the building was gutted. The loss was $645,000. (H-27643.)

Curtiss Candy Co. Fire, Chicago.

Report by Chicago Board of Underwriters
(Member N.F.P.A.).

Fire originating in a motor boat or on the adjoining wharf, on the evening of September 1, 1930, spread rapidly through the one-story wharf sheds, across a 35-foot driveway, and badly damaged two sections of a sprinklered building on the Chicago waterfront. With ordinary glass windows, iron shutters that had been left open,* and highly flammable contents, the sprinklered building was ignited on several floors simultaneously, with such a heavy drain upon the limited water supply that the sprinkler system was ineffective.

Description of the Buildings.

The wharf property where the fire originated consisted of a one-story brick joisted and frame metal-clad structure supported on wooden piles. It was occupied by the Goodrich Transit Co., as a commissary warehouse, and by the Chris Craft Company as a repair and service station for motor boats.

Separated from the wharf buildings by a planked drive 35 feet wide was the candy factory of the Curtiss Candy Company, consisting of a brick semi-mill constructed building divided into three sections of varying height and area. The first section ("A" on the diagram) was six stories in height. The south wall of this section had ordinary glass windows with iron shutters in open* positions. The adjoining section ("B" on the diagram) of the candy plant was two stories in height. In this section the basement and first floor windows had ordinary glass windows with iron shutters, while the second floor on the south side had wired glass in metal sash. The third section ("C" on the diagram) was three stories in height. This section was not involved in the fire. Floor openings in all sections were fairly well protected and the entire plant was equipped with automatic sprinklers.

Origin of the Fire.

There are several theories as to the origin of the fire. One is that it started in a motor boat at the southeast corner of the section of the wharf occupied by the Chris Craft Company. The motor of the boat is said to have backfired, igniting some oily waste in the boat, which caused the gasoline tank on the boat to explode and throw burning gasoline over the boat and on to the adjoining wharf structure. Another story is that the fire originated along the section of the wharf occupied by the Goodrich Transit Company and the Chris Craft Company. Still another version is that it started inside the wharf shed, possibly from spontaneous ignition.

*It is stated that some of the shutters were closed at the time of the fire, but it is apparent that the shutters were open on a sufficiently large proportion of the windows to nullify the value of this form of protection.—Ed.

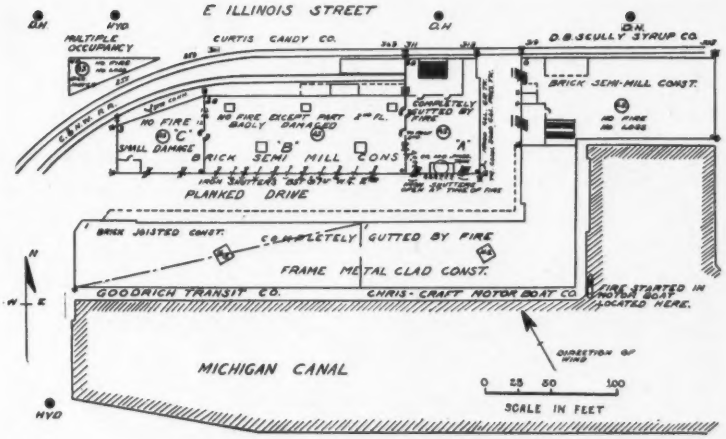


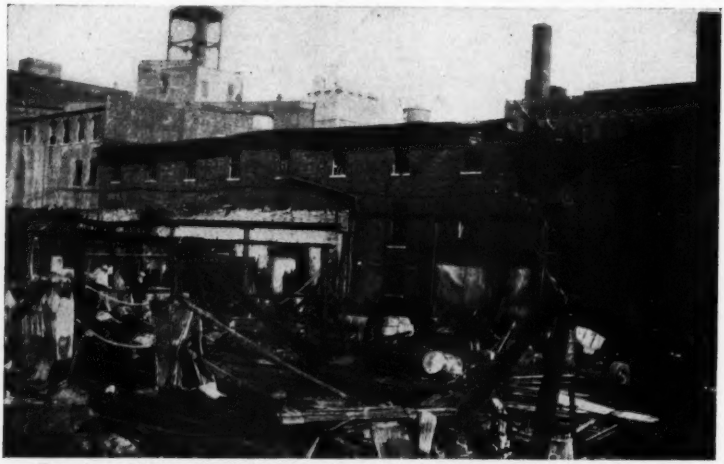
Diagram of Chicago waterfront fire, September 1, 1930.

Story of the Fire.

The fire was first noticed by the superintendent of one of the Curtiss plants located in the neighborhood, who happened to be driving by the west end of the Goodrich Transit Company warehouse and observed the fire in their premises. He sounded an alarm from a city fire alarm box located about a block and a half away. This alarm was received at 7:22 P.M. When the fire department arrived the entire one-story structure occupied by the Goodrich Company and the Chris Craft Company was enveloped in flames and additional alarms were immediately sent in.

At about the same time, or a little later, the watchman employed by the Curtiss Candy Company became aware of the fire. He had started on his first round at 6:50 P.M. and had pulled all the boxes in the two- and three-story sections and those on the four upper floors in the six-story building. He was on the second floor of the latter building when, as he states, he heard an explosion, followed by the breaking of the windows in the south wall of the building. An ember, presumably a window frame, was carried halfway across the floor and landed on a table near the watchman. The building quickly filled with heavy black smoke and the watchman had difficulty in making his exit. He ran to the three-story building, which was not burning, and telephoned the superintendent of the plant and then the fire department.

The fire spread very rapidly and within a very few minutes of its detection the wharf property was a mass of flames. The metal covering on the structure was of little value in confining the fire, due to the rapidity of its spread and the intensity of the heat that developed. The rapid spread of the fire appears to have been due to particularly flammable contents. An exam-



Premises of the Goodrich Transit Co. and Chris Craft Company, showing drums in which gasoline or oil was stored; also damaged roof of two-story Curtiss Candy Company building.

ination of the ruins revealed a number of drums which apparently contained flammable liquid of some sort, although the Chris Craft Company stated that they had but a small amount of gasoline on their premises. It seems probable, however, that flammable liquid was a factor in the spread of the fire, for within a few minutes of the start of the fire the entire rear of the Curtiss Candy Company's building was ablaze, the flames extending from the basement up to and including the gravity tank on the roof, which caught fire and had its top burned off. There was a breeze blowing from the south, but that alone could not account for the rapid spread of the fire.

At about the same time and shortly after the first units of the fire department arrived, the fire entered the six-story building through the ordinary glass windows, the iron shutters having been left open.* Fed by starch deposits and peanut hulls, and fanned by the south wind, the fire traveled rapidly through the entire structure.

As the fire entered the building on several floors simultaneously, a large number of sprinkler heads were fused at one time, which quickly drained the primary supply of the sprinkler system. This supply consisted of 18,000 gallons of water in one gravity and pressure tank. The fire department connected two pumpers to the siamese connection on E. Illinois Street, but the intense heat caused the fourth, fifth and sixth floors and roof of the building to give way, thus rupturing the sprinkler equipment and making it of no value in fighting the fire.

*See footnote on first page of this article.

It is not known just how the fire got into the two-story section of the candy factory. There were standard fire doors between this and the six-story section which functioned satisfactorily, and for a time the firemen worked from the inside of this section. The second story, however, was severely damaged, as was the roof at the end adjoining the six-story structure. The iron shutters and wire glass windows were noted to have been open during the fire.

Six-story Curtiss Candy Company building. Ordinary glass windows with iron shutters open at time of fire.

The firemen surrounded the property and fought the fire from every available point. They worked principally from the street, but also did effective work from the six-story Scully Syrup Company building across the alley, directing hose streams from windows and roof. By this means the fire department saved the gravity tank, which was ablaze, as well as the structure beneath it. The fireboats were effective in fighting the fire in the wharf property. Nevertheless, in spite of their efforts, the firemen could do little other than to hold the fire to the wharf and six-story building completely involved and prevent it from completely wrecking the two-story candy company building and extending to the Scully Syrup Company plant.

The following apparatus was engaged in fighting the fire: 35 pumpers, five ladder trucks, three squads, three high pressure wagons, two water towers, two fireboats, and four insurance salvage patrols.

Sixty-six covers were spread by the insurance patrol, and seven firemen were injured while fighting the fire.

Conclusions and Loss.

From the statements of the watchman of the Curtiss Candy Company and those of fire department officers it is evident that the fire traveled very

rapidly and had completely enveloped the one-story unsprinklered and the six-story sprinklered buildings almost immediately after its detection.

The sprinkler equipment could not possibly hold the fire, due to the large number of sprinkler heads which were opened by the fire communicating to several floors of the six-story sprinklered building simultaneously, with the subsequent draining of the primary water supply. The secondary water supply from fire department pumpers was rendered ineffective by the collapse of the roof and upper floors carrying away the risers.

The wharf property of the Goodrich Transit Company and the Chris Craft Company was practically a total loss, although the wooden floor remained intact. It is estimated that the loss to the warehouse and its contents will be around $200,000.

The plank drive between the wharf structure and the candy factory buildings was little damaged and was in no way a factor in spreading the fire. This plank drive was lower than the surroundings and water rapidly collected in this depression.

The six-story section of the Curtiss Candy Company plant was completely gutted from the basement up, while the two-story section was damaged on the second floor and roof nearest the six-story section. Considerable damage was also caused in the two-story section by water. The difference in the damage done to the two sections of the candy factory may have been due to the fact that the greatest intensity of the fire was opposite the six-story section. Moreover, the two-story section was exposed by a brick wall on the wharf shed, while the wall opposite the six-story section was of frame metal-clad. The loss to the Curtiss Candy Company was estimated at between $200,000 and $300,000.

Burned gravity tank on roof of the six-story Curtiss Candy Company building.

Canadian National S.S. Pier Fire, Vancouver.

By F. F. Dowling,
Fire Branch of the British Columbia Insurance Underwriters' Association (Member N.F.P.A.).

On Sunday, August 10th, at about 3:40 P.M., a fire occurred in the Canadian National Steamship Company's Ocean and Coastwise Shipping Wharf located on Burrard Inlet, Vancouver, B. C., at the north end of Main Street, resulting in the total destruction of the pier and its elevated approach at the south end. The loss was the greatest for a single fire in Vancouver for some time. Fortunately no ships were destroyed and no lives were lost, although several firemen were injured. The structures were being rebuilt and added to, and had but recently been occupied. A considerable amount of interior finishing work was incomplete. An automatic sprinkler system had been installed, but the water supply was not connected. The east transit shed had been placed in service April 30, 1930. The pier was used for coastwise passenger and freight traffic and to a small extent for outward bound ocean-going freighters, the latter being berthed at the west transit shed. Three railway freight cars were on the trackage between the transit sheds awaiting a shipment of paper due the day after the fire. The last boat which berthed at the pier sailed the previous night between 10 and 11 o'clock; there had been no large boats at the pier on Sunday. The property destroyed was owned by the Canadian National Railway, an organization under the control of the government of the Dominion of Canada.

Construction.

The wharf was of frame construction, on open creosoted wood piling above tidewater. The superstructure was built in a rectangular shape, having a two-story section, 130 x 250 feet, at the south or shore end, housing the administration, ticket and general offices, and two one-story transit sheds, 790 feet long, paralleling each other, with a double depressed railroad trackway lying between; these sheds were joined together at the north or water end. The east shed was 90 feet wide and the west shed 70 feet wide. The lower floor of the south section and the other three sections joined and communicated as one large area without a cut-off. An apron 12 feet wide and with 4-inch single plank deck extended around three sides of the pier beyond the superstructure, there being no apron at the shore end.

The dock embodied practically none of the modern suggested methods of fire prevention from a structural viewpoint. There were no draft curtains in the roof and no division walls, except a so-called fire wall of wood, double, two inches in thickness, about midway in the east shed; this wall extended from the top of the flooring to the underside of the roof, but did not extend under dock. The main floor was of 2 x 4-inch laminated cedar construction

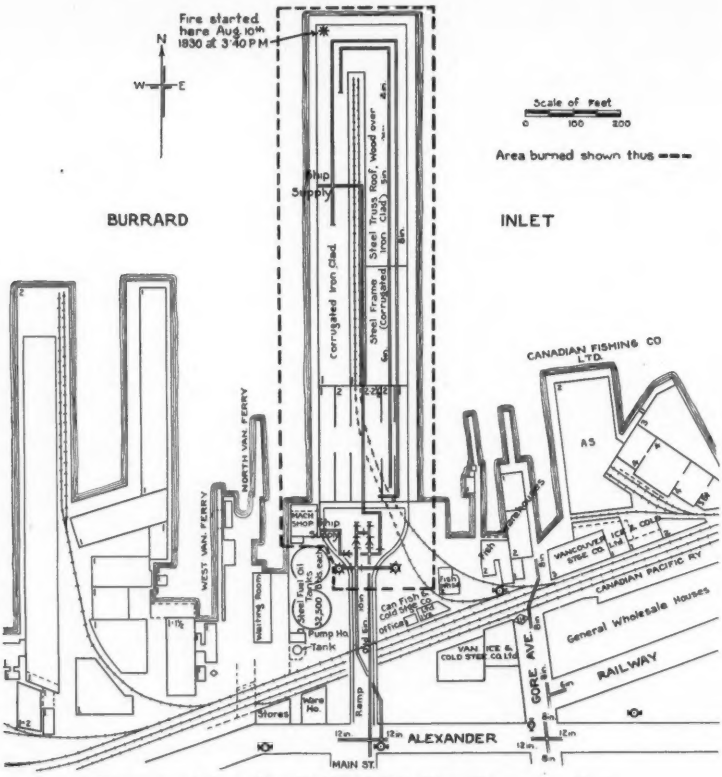


Diagram of Canadian National S.S. Pier, Vancouver, B. C.

with a 3-inch asphaltic covering, except that asphaltic covering had not been laid in a small section of the floor inside the shed at the northwest corner. There were openings in the floor 10 x 10 inches with covers, spaced at 50-foot intervals and door openings in the sidewalls of track depression opening into underneath space. There were no fire hatchways in floor and no walk-ways under floors. There was an entire lack of bulkheads under the floor of the pier. The roof was of 5-ply composition on the two-story section and 3-ply on the one-story section on 1½-inch wood sheathing on wooden trusses, except there were steel trusses in the one-story transit shed on the east side. The side walls were metal-clad, except that the upper walls of the two-story section were of drop siding. The walls of the east transit shed were on metal frame.

Fire Protection.

There were four standpipes along part of one side of the track depression fed by a 5-inch main, each with 50 feet of 2½-inch hose; these were not used during the fire. A few one-quart tetrachloride extinguishers had been installed

and five night watch and fire alarm boxes were in use, also watchman's service was being maintained. These boxes were part of the installation in the original pier and were located at the shore end.

Automatic sprinkler equipment had been installed throughout the structure, except in space underneath the lower floors above tidewater; but for some reason not determined, the underground main was but partially installed and no connections had been left for the sprinkler equipment. The connections forming the supply to the underground main were to consist of a 10-inch and 6-inch connection to the city system on Alexander Street. The 10-inch connection had been completed to the valve pit only two days previous to the fire, although a great part of the pier had been occupied for shipping for two months or so; and as a further indication of the lack of interest shown in providing fire protection, the portion of the fire main which was installed lacked about 100 feet of pipe to provide a connection from the valve pit. If this, and cross connections from the fire main to the sprinkler systems, had been provided simultaneously with the completion of the city connection, a different story undoubtedly could have been written. A bright spot in this hiatus consisted of two six-way hydrants which had been installed two days previous to the fire on the 10-inch main about 100 feet from the south end of the pier under the elevated concourse. One of these proved of value to the fire department, the other was not available on account of intense heat.

The Story of the Fire.

As far as can be determined from statements made by individuals who were in a position to observe the fire in its early stages, it started about 3:40 P.M., on the upper face of the 12-foot apron a few feet east of the northwest corner of the pier, a small flame being noticed which in a very short time extended downwards involving the space under the pier. In a few minutes, possibly four, it curled up into the superstructure and from that stage onward the progress both in the super- and substructures was extremely rapid. The watchman was in the baggage room and was about to be relieved by the oncoming watchman; the latter on entering the pier had noticed smoke at the northwest corner and turned in an alarm. They then attempted to fight the fire with carbon tetrachloride extinguishers.

The alarm was received over the telephone and transmitted promptly at the fire department at 3:52 P.M., followed by alarms transmitted from the district telegraph central station.

On first alarm District Chief Eaton was in charge. On arrival he ordered one line of 1250 feet to be laid into the seat of the fire from the 6-way hydrant under ramp, and one line of 2000 feet from hydrant north of C.P.R. tracks at Gore Avenue; upon his arrival the northwesterly part of the dock for about 250 feet was heavily involved in flames and smoke, which advanced so rapidly that the men were forced to retire, being barely able to save the

The Canadian National Steamship Co. pier, Vancouver, destroyed by fire on Aug. 10, 1930, with a loss over $1,000,000. This wooden pier, over 1000 ft. long, had no bulkheads or other fire break in the substructure, and in the pier sheds there was no adequate barrier to the spread of fire. An automatic sprinkler system had been installed, but the water supply was not connected. No fireboat protection was available, due to a controversy as to whether the city or the waterfront property owners should pay for admittedly needed fireboats. This picture was taken from the outer end of the pier. The fire started near the corner in the center foreground.

fire department trucks and having to abandon the hose lines before water was available. The rapid spread in the superstructure was hastened by draught caused through a number of the side doors being open; open doors also permitted ready access by fire from the west shed. It is stated that the metal-clad fire door on the 4-inch division wall in the east shed closed automatically, but the wall proved ineffective. Deputy Chief Loftus arrived from headquarters shortly after the first alarm and assumed direction of operations. He immediately turned in a third alarm, 4:01 P.M. The structures being doomed, efforts were concentrated upon saving exposures. Several structures in the vicinity were ignited but were saved from complete destruction, except the C.N.R. machine shop southwest of the main pier, which was completely destroyed.

The fire department made the best of a losing battle, handicapped as they were through lack of fireboats* and by the narrow space for operation between the C.P.R. tracks and the burning structure. Their efforts, combined with the fact that a very gentle breeze only prevailed, were responsible for confining the fire to the area burned and preventing a conflagration of unknown extent.

A fuel oil depot of the Imperial Oil Company, south of the dock and adjacent to the auto concourse, was severely exposed at one stage of the fire. The depot consisted of a concrete pump house, a loading rack and three all-steel fuel oil storage tanks. The main tanks consist of two 32,500-barrel tanks, 76 feet in diameter by 40 feet high, each surrounded by concrete fire walls 88 feet in diameter by 34 feet high by 13½ inches thick, capable of holding 15% over the capacity of the tanks. No other protection against fire is provided. The 750-barrel measuring tank was without fire protection. Fuel oil was received through an 8-inch line and discharged through a 6-inch and 4-inch line under the pier, also discharged underground through a 4-inch line to the filling racks.

During the fire the 8-inch receiving line and the 6-inch and 4-inch discharge lines laid under the wharf were completely destroyed, a section of the platform of the filling rack was destroyed and the running board and paint on one tank car burnt, but tank otherwise was undamaged. A section of the roof on the 32,500-barrel tank nearest the dock was damaged by heat for a distance of approximately 60 feet along the upper circumferential joint, causing a number of rivets to shear, and resulting in a section of the tank wall for a distance of approximately 10 feet to bulge inward for a distance of approximately five inches. At the time of the fire the tanks were full of oil and this no doubt protected them by the conduction of the heat from the hot plates to

*The city of Vancouver has a single fireboat stationed on False Creek. This boat protects an industrial district some distance from the fire and it was apparently considered inadvisable to bring the boat around to Burrard Inlet, thus leaving the False Creek area without protection.—Ed.

the oil. The fire department concentrated numerous heavy streams on the tanks, thereby preventing the complete rupture of the north tank.

The pier was entirely destroyed, except that practically all piling remained sound below about mean tidewater level; and the elevated ramp was saved from Alexander Street to just north of the C.P.R. tracks. The fire was under control about 5:30 P.M.

Cause of Fire.

The cause of the fire cannot be definitely determined. The appearance of the fire in the first stages was of shooting flames and an apparent absence of smoke, at least to any marked degree. No one was seen in the vicinity of the fire, and the watchman states that there were no strangers on the pier. It is known that a few men were working for sub-contractors, but none apparently in the section where the fire originated. Some oakum had been used during the week previous for caulking joints near the northwest corner, but sweepings had been removed by wheelbarrow and dumped at the south end. A few weeks previous to this fire the conditions pertaining to cleanliness were such that the fire wardens requested a general clean up, which was done.

A small fire occurred on this dock on June 20th, also in the northwest corner, but inside of the shed.

Loss.

The estimated loss is $1,050,000, with an insurance loss, apart from marine insurance, of $520,000. The goods on the pier at the time of the fire consisted of canned salmon, canned fruit and aeroplane spruce to the value of $50,000, also goods of general description for local points to the value of $17,000. The steamship company had values in ships' furnishings and general stores and machine shop of approximately $188,000, the automatic sprinkler equipment $58,000, and the structure itself, $700,000. There were also a number of automobiles belonging to officials of the steamship company parked on the pier.

Conclusions.

The almost utter lack of fire protection on so important a waterfront as that existing in the City of Vancouver has been the subject of controversy for many years. Here is a harbor of importance second to none on the Pacific Coast, with a fore-shore of 6.17 miles in length, very well built up and quite congested for the major portion of it, without adequate fire protection in the way of large mains or even in many places of any mains whatever; coupled with the fact that the physical conditions are poor, in many instances large unbroken frame areas over tidewater, and no fireboat protection.

The fire, as described herein, has been predicted for a long time. Quite an exhaustive report from the Fire Branch of the British Columbia Insurance Underwriters' Association was forwarded to the Mayor of the city in August, 1929, following a large dock loss about a quarter of a mile west from where

this fire took place. As a result of last year's fire the Vancouver Board of Trade appointed a special committee to deal with the lack of fire protection in the harbor generally, but owing to the fact that the harbor is under the jurisdiction of a Board of Harbor Commissioners appointed by the Dominion Government at Ottawa, the Aldermen of the City of Vancouver have not assumed what many believe to be their rightful duty and provided proper fireboat and other fire protection. Even at the present time, after this fire has brought home to them the immediate need of proper protection, there is a deadlock existing between these two bodies, but it is hoped that the Citizens' Committee will be successful in obtaining fireboat protection before next year.

In the report of the Underwriters' Association they mention that to protect the waterfront adequately two fireboats should be installed under the control of the city fire department; large water mains and hydrants should be installed to parallel the waterfront; many additional fire alarm boxes provided, and also structural changes to prevent the sweeping of fire through and under vast pier warehouse interiors; installation of automatic sprinkler systems on the larger piers; bulkheads under wharves, and draught curtains in the roof areas.

There is no new lesson to be learned from the fire. Practically none of the precautions which ordinarily are expected in a building with the value and importance of this one were taken. Here was a pier over 1000 feet long with practically an unbroken area both under the floor and in the superstructure. The rapidity with which the fire traveled is almost inconceivable. Within 15 minutes the entire pier was enveloped in flames. The building was equipped with an automatic sprinkler system which had been completed for a month previous to the date of the fire, but for some reason not determined a separate contract was let for the underground system, delays were occasioned in it, and at the time of the fire the workmen were proceeding with the installation of this work. The lack of wind undoubtedly saved a sweeping conflagration. The blackened stumps of the piling, twisted steel beams and black encrusted timbers now stand in mute testimony of indifference and the lack of applying common sense. It would be too high a price to pay if by such fires the whole retail and wholesale section of a large city should be devastated.

Loss of Life in Sprinklered Fires.

The first comprehensive statistical data relative to loss of life in sprinklered buildings were compiled by the N.F.P.A. Department of Fire Record and published in the QUARTERLY for July, 1923. They supplemented and confirmed the brief surveys made by the N.F.P.A. Committee on Safety to Life in 1914 and 1916.

The record of 1923 indicated that out of 35,000 fires occurring in sprinklered buildings, loss of life occurred in but forty-five, or slightly more than a tenth of one per cent. These forty-five fires originated from many different causes and in many occupancies. The handling of highly combustible and flammable materials and liquids, such as gasoline, naphtha, pyroxylin plastics, etc., creates a life hazard which sprinklers cannot be expected to provide against. It is surprising how few such casualties are reported.

The total loss of life in sprinklered buildings from 1898 to 1923, as shown by the records of the National Fire Protection Association, amounted to two hundred and two persons. Of these, the majority lost their lives in serious explosions or rapidly spreading flash fires which sprinklers should not be expected to control. It seemed reasonable, therefore, to reaffirm the conclusion of the Committee on Safety to Life: "That it is today an almost unquestioned fact that the automatic sprinkler affords the largest degree of protection of life against fire in practically all cases where there is combustible construction or material, the rapid burning of which is liable to be a menace to the lives of the occupants of the building."

It is more than seven years since these data were compiled and published. The question has frequently been asked as to the validity of the conclusions, particularly in view of the increased development and use of more flammable and hazardous processes and materials. To supply an answer to this question the Department of Fire Record has made a supplementary research. The following data summarize the results of this investigation:

	1898-1923	1923-1930	Total
Number of sprinklered fires reported	35,000	17,303	52,303
Fires in which loss of life occurred	45	74	119
Number of lives lost in these fires	202	184	386

An analysis of the operation of the sprinkler systems in the 119 fires since 1923, involving loss of life, indicates that in sixty-six fires, or 55.4%, sprinklers were effective in extinguishing the fire or held it in check, thus preventing greater loss of life and property. Explosions occurring previous to or in the early stages of the fire crippled the sprinkler system in twenty-four instances,

or 20.5%. In ten cases the system had been shut off. In but twelve fires, or 10% of the total, was the operation of the system unsatisfactory. Of these, all were due to inadequate water supplies, obstructions to distribution, and/or sub-standard installations rather than to the failure of the heads or system itself to function.

Operation of Sprinkler System.

Action of Sprinklers	1898-1923 No. of Fires	%	1923-1930 No. of Fires	%	Total No. of Fires	%
Extinguished fire	19	42.2	18	24.4	37	31.1
Held fire in check	5	11.0	24	32.5	29	24.3
Total satisfactory	24	53.2	42	56.9	66	55.4
Crippled by explosion	13	28.8	11	14.8	24	20.5
Shut off	2	4.5	8	10.8	10	8.4
Unsatisfactory	4	9.0	8	10.8	12	10.1
None opened	2	4.5	5	6.7	7	5.6
Total	45	100.0	74	100.0	119	100.0

Detailed statistics of sprinkler operations were not included in the previous analysis, but the seventy-four fires occurring from 1923 to date have been further analyzed in the following tables.

Operation of Sprinkler Systems, 1923-1930.

Action of Sprinklers	Wet	Dry	No Data	Total
Extinguished fire	14	3	1	18
Held fire in check	14	6	4	24
Total satisfactory	28	9	5	42
Crippled by explosion	3	4	4	11
Shut off	4	2	2	8
Unsatisfactory	4	3	1	8
Total operated	39	18	12	69
None opened				5
Total				74

In eight instances where loss of life occurred the sprinkler system had been shut off. The reasons for this were stated on the original reports as follows:

Shut off too soon by firemen	3
Shut off for winter	2
Shut off due to freezing	1
Shut off due to minor air leak	1
Shut off due to hazard of water in manufacturing process	1

It may be noted that in three of the fires where the systems had been shut off this condition contributed directly to the loss of life.

The eight unsatisfactory sprinkler fires were chargeable as follows:

Inadequate water supplies	3
Obstruction to distribution and inadequate water supplies	2
Hazard too severe for system	2
Slow operation of dry system and large number of heads opened	1

Of the four fires occurring in the period 1898-1923 where the operation of the sprinklers was unsatisfactory, in not one could the loss of life be attributed to the failure of the sprinklers. An analysis of the eight fires recorded since 1923, however, indicates that in three instances the unsatisfactory operations of the sprinkler system were indirectly responsible for loss of life. In all three it appears that inadequate water supplies and/or sub-standard installation features prevented or retarded the proper operation of the system, thus permitting the rapid spread of fire, which trapped the victims before they could reach available exits. This emphasizes the necessity and value of proper installation and maintenance of automatic sprinkler systems.

The table which follows indicates the cause of the loss of life rather than the cause of the fire or action of the sprinklers.

Causes of Loss of Life in Sprinklered Buildings.

Cause	1893-1923		1923-1930		Total	
	No. Fires	Lives Lost	No. Fires	Lives Lost	No. Fires	Lives Lost
Explosions	20	124	38	132	58	256
Flash fires	17	34	5	7	22	41
Firemen killed in performance of their duties	2	3	9	17	11	20
Clothing ignited	0	0	8	11	8	11
Rapid spread of fire	2	2	5	6	7	8
Sprinklers shut off	2	4	3	5	5	9
Suffocation by fumes	1	3	4	4	5	7
Building collapse	1	32	0	0	1	32
Re-entering burning building	0	0	1	1	1	1
Workman fell and lantern started fire	0	0	1	1	1	1
Total	45	202	74	184	119	386

Note: Eight of the firemen killed lost their lives in explosions and two were killed by fumes. The remainder lost their lives due to miscellaneous causes, such as falling walls, etc.

This analysis confirms conclusively the value of automatic sprinklers as a safeguard to life against fire. It is apparent that even when the hazard of explosions or flash fires exists they are effective in many cases. There are but two cases in the N.F.P.A. fire records where loss of life has occurred in a mercantile, hotel, apartment or similar occupancy. One of these instances was a fire in a dry goods store which was gutted on the top floor by an exposure fire and two firemen were killed by a falling wall. The other was a fire in which a fireman lost his life due to fumes from burning celluloid stock inhaled when he entered the building.

Typical Loss of Life Fires in Sprinklered Buildings.

Space will not permit a summary of all the fires included in this record, but a brief account of the important features in some of the fires is given below. The fires chosen for this review are typical of their respective groups.

Explosions.

AUGUST 31, 1923. COAL TAR PRODUCTS, PHILADELPHIA, PA. A fire occurred in a three-story semi-fire resistive building following a violent explosion in a naphthalene still. The explosion tore off the top of the still, badly damaged the building and crippled the sprinkler system. Five men were killed and fourteen were injured by the explosion. (S-36119.)

NOVEMBER 8, 1923. CORK FLOORING MFG., NEW YORK, N. Y. Shortly after blower system had been shut down, fire was discovered near the ceiling of the boiler room. The fire was thought to have been extinguished when a severe explosion took place, probably due to ignition of cork dust. The watchman's clothing was ignited by the explosion and he was fatally burned. Two sprinklers (wet) opened and held the fire in check. The loss was moderate. (S-36283.)

NOVEMBER 9, 1923. COAL TAR PRODUCTS, BUFFALO, N. Y. Three lives were lost when an explosion wrecked a one-story brick building occupied by the indigo department of the plant. A mixing and storage tank containing some 16 tons of caustic soda and sodamide in a molten state burst or exploded. It is thought that the explosion may have been due to some water being blown in when compressed air was admitted to the discharge side of the tank. On account of the hazard of water the sprinkler system had been disconnected prior to the time of the explosion. There was little fire in the building except from pieces of roof and broken gas piping. The fire was extinguished by three hose streams. The loss from the explosion was considerable. (S-36529.)

AUGUST 12, 1924. BLEACHERY, PAWTUCKET, R. I. Two pails of benzol had been added to the warm water in a washing machine when, without warning, an explosion occurred. The explosion was due to the ignition of the benzol vapor by a spark from an electric motor. An employee operating the machine was fatally burned. Ten sprinklers opened and, together with a hose stream, extinguished the fire. Loss $100. (S-38075.)

AUGUST 29, 1924. GARAGE, PITTSBURGH, PA. Eleven lives were lost in an explosion which occurred when the driver of a gasoline tank truck opened the cover on one of the compartments of the truck while the motor of the machine was running. The tank evidently was under considerable pressure, as a large quantity of gasoline spray was evolved an instant or so before the explosion took place. It is thought that the relief valve on the top of the tank was inadequate. The fumes or spray from the tank were ignited by the exhaust, and the driver, six other employees and four children who were

playing in the street were fatally burned. Twenty-five sprinklers (wet) operated and held the fire in check. The fire was extinguished by three fire department hose streams. Loss moderate. (S-38672.)

SEPTEMBER 2, 1924. CEREAL MILL, GREENFIELD, WIS. A dust explosion and fire destroyed a ten-story cereal and feed mill and adjoining structures of the plant. An employee working on the eighth floor lost his life. He was involved in the first flash but escaped unassisted by way of the enclosed stairway, the fire in his clothing being extinguished by automatic sprinklers. He was, however, severely burned and died in a hospital several days later.

It is thought that the fire may have been due to the contact between the iron buckets of the elevator and some foreign substance, possibly a nail or stone. Two severe and several minor explosions occurred at the start of the fire. It is probable that the original flash fire opened up sprinklers on at least two of the upper floors, involving about 100 heads. In that case, the 4000-gallon supply from the pressure tank would have been exhausted in less than one minute's time. The subsequent opening of the large number of heads on the lower floors, and the probable disruption of the sprinkler piping, apparently consumed the entire supply from the fire pump, which prevented the water from reaching the upper floors. Loss large. (S-38226.)

FEBRUARY 7, 1925. MOTION PICTURE FILM LABORATORY, FORT LEE, N. J. A short circuit ignited exposed film in the joining room. The fire was held in check by automatic sprinklers and was quickly brought under control by fire department hose streams. About an hour after the fire started and when it was considered under control, a terrific explosion occurred, lifting the entire building from its foundation and forcing out practically the entire north wall. About twenty employees and firemen outside of the building were injured and two of them died from their injuries.

Considerable stock from the film vaults was piled on the basement floor near an air conditioning apparatus which leads to the joining room, where the fire started. It is believed that heat or sparks were carried from the adjoining room to this pile of film by means of this apparatus, causing rapid decomposition, and an explosion was inevitable. The loss was approximately $1,000,000. (S-39048.)

APRIL 29, 1926. RUBBER WORKS, MALDEN, MASS. The varnish and cement building of the plant was destroyed and two employees lost their lives when two explosions wrecked the building and started a fire which lasted several hours. The first explosion occurred in the varnish mixing room in the center of the building and was followed almost immediately by an explosion in the churn room. The cause of the explosion is unknown, as both attendants in the buildings were instantly killed. Many of the sprinkler pipes were broken, so that the water was shut off and the fire extinguished by foam and hose streams. Loss $30,000. (S-39875.)

SEPTEMBER 17, 1926. SHOE FACTORY, NEWBURYPORT, MASS. An explosion of a partially filled drum of disinfectant in the basement of the factory fatally burned an employee and resulted in a flash fire which was entirely extinguished by sprinklers. It is believed that the employee went to the basement in order to get some of the disinfectant for home use and struck a match in order to examine the amount in the nearly empty drum. The resulting flash of the vapors inside the drum caused the explosion. The loss was small. (S-43193.)

NOVEMBER 22, 1925. FURNITURE FACTORY, INDIANAPOLIS, IND. A metal chute from the cyclone separator on the roof to the boilers had become clogged and workmen were trying to remove the obstruction with a pole. Fine wood dust formed a cloud which was ignited by the boiler fire. A mild explosion followed which ignited the oily clothing of one of the workmen and he was burned to death. Seven sprinklers (wet) opened and practically extinguished the fire. The loss was slight. (S-44329.)

JANUARY 25, 1927. CEREAL AND FEED MILL, CEDAR RAPIDS, IOWA. Fire followed a dust explosion which occurred in the feed building. Sprinklers (dry pipe system) and hose streams prevented severe damage to other buildings of the plant. It is thought that a primary explosion occurred on the second floor and another, quickly followed by another on the sixth floor, which crippled the sprinkler system. Two men on the second floor were rescued after they had been severely burned, and a workman on the sixth floor lost his life. Sprinklers were seen to operate on the second floor from which the two men were rescued. The loss was large. (S-43996.)

APRIL 23, 1927. AUTOMOBILE BODY PLANT, DETROIT, MICH. The fire started on the third floor of a five-story semi-mill constructed building in the section where the lacquer spraying is done. It was due, apparently, to the ignition of pyroxylin dust or residue by a spark from the auxiliary equipment of a mercury vapor lamp over a spray booth.

Before the switch controlling the lights could be pulled, a mild explosion occurred, followed by a second explosion of greater violence which wrecked sprinkler piping, booth equipment and vents, and probably some of the pipes which supplied lacquer to the booths from tanks on the floor above.

Apparently the first explosion was enough to shake pyroxylin dust (of which there was considerable on the ceilings and on objects in the room) into the air, and the second explosion was probably partly a pyroxylin dust explosion and partly an explosion of the gases formed by the decomposition of residue from the heat of the first flash. Several workmen were killed outright by the blasts and others died later of their burns. In all 23 lost their lives. The fire spread rapidly through the buildings, as the sprinkler system was out of service due to the explosions. Loss $2,000,000. (S-44713.)

DECEMBER 14, 1927. CARBON WORKS, FOSTORIA, OHIO. An explosion occurred in a pipe tunnel in process of construction under the building. The explosion was due to the ignition of gas escaping from a two-inch uncapped end which was overlooked before gas was turned into the pipe. An electrician inside the building on a ladder near one of the manholes was blown against the wall and fatally injured. One sprinkler operated when struck by débris from the explosion, but was promptly turned off. Loss due to explosion $60,000. (S-46557.)

NOVEMBER 2, 1928. AUTOMOBILE FACTORY, CLEVELAND, OHIO. An explosion occurred in a japan oven due to the presence of an explosive mixture and insufficient ventilation. There were eight men working in the building at the time; one was killed and the others were injured. A small fire in the drain board and dipping tank followed the explosion, but this was controlled by the automatic sprinklers and automatic foam equipment. Loss $17,000. (S-52168.)

DECEMBER 23, 1929. PRINTING PLANT, MONTREAL, P. Q. An employee in the pressroom was drawing gasoline from a drum by means of a hand operated bilge pump when a fire occurred in the pump, presumably from a spark due to friction. This employee ran from the room and shouted to fellow workmen that the pump was on fire. The fire door to the room was closed at the time and fumes of gasoline apparently filled the room, for when employees came in with foam extinguishers and opened the door a severe explosion occurred, spreading burning gasoline around the pressroom and severely burning four employees, three of whom died. The fire was practically extinguished by sprinklers (wet system). Loss moderate. (S-51700.)

JANUARY 1, 1930. FLOUR MILL, ENID, OKLA. An employee was killed by a dust explosion which occurred in the basement of an eight-story fire-resistive mill building. The fire was extinguished by chemical extinguishers as there was not sufficient fire to operate the automatic sprinklers. Loss estimated at $2000. (S-51949.)

SEPTEMBER 18, 1930. COLD STORAGE WAREHOUSE, GLOUCESTER, MASS. A leakage of the ammonia from the refrigerating system had occurred and the engineer, long in charge of this equipment and thoroughly experienced, is reported to have attempted to stop the leaks at the rectifier. While he was engaged in this, and his helper was in the room, an explosion is reported to have occurred, as a result of which the boiler room was filled with steam and ammonia fumes. Almost immediately there was another mild explosion and a severe blast of flame. The fire department was called, but eleven sprinklers operated, entirely extinguishing the fire. The engineer was burned and scalded to death, while his helper was severely injured. Loss estimated at $20,000. (S-52253.)

Flash Fires.

NOVEMBER 2, 1923. SHADE CLOTH FACTORY, OSWEGO, N. Y. A drum of benzine was spilled at the bottom of elevator shaft and was ignited probably

from an electric spark. The elevator shaft was frame with wood doors. Flame flashed up the shaft and out on the second floor landing. An employee was caught in the flash and was burned to death before he could get out of the shaft. Two other employees were fatally burned when they entered the fire area in an attempt to rescue the first victim. One sprinkler head in the shaft (wet system) and hand chemicals extinguished the fire without loss. (S-36747.)

MAY 13, 1925. AUTOMOBILE FACTORY, ST. LOUIS, MO. A flash fire, from unknown cause, occurred while an employee was cleaning up the pyroxylin enamel room. One man was burned to death and two others were slightly burned. Nine sprinklers (wet system) operated and practically extinguished the fire. Loss $200. (S-39721.)

MARCH 10, 1926. CLOTHING MFG., NEW YORK, N. Y. A flash fire occurred in the dry cleaning room and a woman employee lost her life. One sprinkler (wet) operated and entirely extinguished the fire. The loss was small. (S-42139.)

APRIL 25, 1928. PAINT AND VARNISH WORKS, MALDEN, MASS. An employee was preparing a special shipment of solvent. He was pouring toluol from a measure through a metal funnel into a fifty-gallon drum containing benzol. A flash fire occurred, probably caused by a static spark. The liquid in the measure, which amounted to about one gallon, ignited. Three employees were severely burned, one of whom died as the result of his injuries. The flash and heat from the burning liquid opened eight sprinklers (wet system). The cooling effect of the sprinklers probably prevented an explosion of the various drums of flammable liquids in the room. The loss was small. (S-47305.)

MARCH 19, 1929. AUTOMOBILE BODY PLANT, DETROIT, MICH. Fire occurred in a spray booth on the third floor when pyroxylin dust in the booth was ignited by a broken electric light bulb in the hands of one of the workers. The man had entered the vent duct of the booth with the light, which was strictly against orders. He was fatally burned by the resultant flash before he could escape from the booth. Automatic sprinklers extinguished the fire in the booth and open sprinklers extinguished the fire in the stacks. Loss $400. (S-52170.)

Firemen Killed.

DECEMBER 5, 1926. AUTOMOBILE BODY PLANT, BUFFALO, N. Y. Fire occurred in a two-story brick dry kiln and lumber storage building from an unknown cause. The building was equipped with an old dry pipe sprinkler system with sub-standard pipe sizes and spacing, and unapproved heads. Sprinkler lines were obstructed by lumber piles. The fire continued to gain headway despite the sprinklers and, due to a delayed alarm, the fire department was late in reaching the scene. Two of their pumpers took suction from yard hydrants, which were fed by sprinkler mains, and this soon drained the 40,000-gallon gravity tank, making the sprinklers almost worthless. Later the

roof collapsed, forcing out the south wall, killing two firemen and seriously injuring two others. Loss $75,000. (S-41177.)

APRIL 21, 1926. WOOD WORKER, MILWAUKEE, WIS. A fire, which apparently started in unused conductor pipe holes in the brick wall of a shavings bin, worked its way back into the pile of shavings in the form of a glowing mass. Sprinklers had apparently quenched the fire and were ordered shut off by the firemen. One corner of the bin was covered by a head which did not operate and was not thoroughly wet down, which fact the firemen did not know.

The door at the bottom of the shavings vault in the boiler room was opened in order to empty contents on to the boiler room floor, and the sawdust was pulled out of this door without being wet down. In the process of emptying the bin the boiler room was filled with floating dust. A cave was formed in the vault in which the fumes generated by the combustion of the sawdust accumulated. When the cave had been finally enlarged to a point where the fire tumbled in, the fumes inside of the vault ignited. This slow flash apparently communicated to the dust laden air in the boiler room, and a violent explosion occurred. The intensity of the heat generated by the explosion ignited the clothing worn by the firemen, one of whom was killed instantly and five others died later. Loss $10,000. (S-42364.)

JUNE 28, 1926. MERCANTILE, BOSTON, MASS. Fire thought to have been due to the spontaneous ignition of celluloid stock on shelves gave off heavy smoke and fumes. One fireman died from the effects of these fumes and four others were seriously affected. Four sprinklers (wet system) opened and held the fire in check, due to the plentiful water supply, small area, and the fact that a majority of the celluloid stock was confined in boxes. Loss $19,475. (S-42483.)

OCTOBER 16, 1927. DRY GOODS STORE, PITTSBURGH, PA. Two firemen were killed when a wall fell under the weight of a gravity tank which collapsed as its supports were weakened by the fire. The operation of the sprinklers was unsatisfactory, as the water had apparently been shut off by the fire department to prevent water damage before the fire entered this building from a burning structure adjoining. The fire entered the top floor, which was gutted, allowing the tank to collapse. Loss $1,233,273. (S-46110.)

FEBRUARY 29, 1928. PAPER MILL, NORTH CHATTANOOGA, TENN. Fire occurred in the paper warehouse of the plant when an employee, preparatory to using a portable electric elevator for hoisting baled paper, proceeded to plug a long extension cord into the electric circuit. The cord was connected by a two-piece plug, which short circuited, causing a flash which ignited loose paper in the vicinity. Employees tried to beat out the fire, but being unsuccessful, they called the fire department. Before the fire department arrived the sprinklers opened and checked the fire (dry system). Upon arrival the fire

department ordered the sprinklers shut off as no fire was visible. A group of firemen had entered the building with a line of hose, when, within two minutes after the sprinklers were shut off, a back draft flashed through the room. In trying to escape one of the firemen fell and was suffocated before he could be rescued. The warehouse was destroyed with a loss of $43,344. (S-46980.)

JANUARY 3, 1929. METAL STAMPING, NEWARK, N. J. Fire was due to one of the tallow pots in the building boiling over and igniting. Sprinklers under the roof operated, but the water could not reach the enclosure where the pots were located. The sprinklers prevented the spread of the fire to tallow barrels stored near by. The firemen on arrival used three hose lines and six 2½-gallon foam extinguishers, extinguishing the fire in about two hours. A company of firemen on the roof had been using a hose stream through a small hole cut near the chimney. As they were preparing to withdraw, the chimney crumbled and fell, tearing a hole in the roof and carrying two of the men down through the hole and burying them in the débris. One of the men died of his injuries. The loss was approximately $2000. (S-51912.)

Clothing Ignited.

NOVEMBER 17, 1924. RUBBER WORKS, TRENTON, N. J. An employee was using gasoline to soften rubber cement used in putting tread on automobile tires. A flannel rag, which was being used in rubbing it on the tire, ignited, due to friction. At the sight of the fire the workman evidently became confused and spilled gasoline on his clothing. The clothing was burned from his body and he died within 48 hours. Four sprinklers (wet system) opened and practically extinguished the fire. The loss was small. (S-38922.)

APRIL 28, 1927. COTTON MILL, EAST NEWARK, N. J. An operator had thrown the switch to start a motor drive on a ring spinning frame when an electric arc occurred, blowing off the cover of a fuse box and igniting the operator's clothing and lint and banding on five adjoining frames. The employee was fatally burned. The fire was extinguished by one hose stream and several fire pails. The fire was not severe enough to operate the sprinklers. Loss estimated at $300. (S-44847.)

DECEMBER 11, 1928. GARAGE, SALEM, MASS. Fire occurred in the clothing of an employee who was working underneath a truck. The cause of the fire is unknown, but is thought to have been due to the ignition of a match in the man's pocket. The fire in his clothing was extinguished by a hose being used to wash an automobile, but not until after the man had run through the building with his clothing aflame and been so severely burned that he died later. The fire in the room where the accident occurred was extinguished by two (wet) sprinklers. No property loss. (S-48882.)

JULY 15, 1929. COAL TAR DYE STUFF, BUFFALO, N. Y. Fire occurred on the second floor of a three-story brick building. Operator was recharging the

thio-carbanolide kettle. He appears to have been mistaken about the amount of aniline water in kettle, and in attempting to draw the excess out to an open floor drain, drew out carbon-bisulfide on floor. This ignited, either spontaneously or by contact with other chemicals on floor. Operator appears to have fallen into flame which sprung up from floor and was fatally burned. Twenty sprinklers (dry) held the fire in check and it was extinguished by one private hose stream. Loss estimated at $1000. (S-51146.)

JANUARY 24, 1930. METAL WORKER, SPRINGFIELD, OHIO. Fire occurred on the second floor of a five-story brick-joisted building. On this floor steel grave vaults are washed with naphtha to remove grease. Work had just started for the day and employees had brought in several pails of naphtha from the 100-gallon drum in the yard. One of these pails was placed on a bench near a steam radiator and a moment later it was noted to be on fire.

Becoming panicky, the men decided to throw the pail of naphtha out of the window. One of them opened the window while the other attempted to throw it out. In so doing he spilled the entire contents over the other man and the floor. The man, enveloped in flames, ran madly through the plant until he was tripped and the flames smothered with burlap bags. He was fatally burned. Eight sprinklers (wet system) operated and extinguished the fire. Loss $3000. (S-52169.)

APRIL 7, 1930. ARTIFICIAL LEATHER, WEYMOUTH, MASS. The fire occurred in the loading room on the second floor, where an employee was placing film scrap in a churn. A static spark ignited fumes from the churn, together with 250 pounds of scrap. The employee loading the churn had his arms full of scrap and was fatally burned. The fire was held in check by the operation of 62 sprinklers (wet system) and was extinguished by four fire department hose streams. Loss $3000. (S-51832.)

Rapid Spread of Fire.

MARCH 6, 1924. GLASS WORKS, LANCASTER, OHIO. The sprinkler system was not in service due to a minor air leak. Employees tried to fight the fire with chemicals and later by streams from yard hydrants, but the fire spread so rapidly that they were unsuccessful and one employee was trapped and lost his life. The watchman then arrived from another part of the plant and turned on the sprinklers, but by that time the fire was beyond control. Owing to the large number of sprinklers operating and the reduced pressure brought about by this condition the effect of the sprinklers was nil. Loss $540,000. (S-36971.)

NOVEMBER 30, 1926. FURNITURE FACTORY, LENOIR, N. C. Fire occurred in a spray booth in the finishing building, due to the improper handling of the spray gun while being cleaned in close proximity to unprotected incandescent lamps. The electric bulb at the booth entrance was broken and there was an immediate flash of flammable vapors throughout the second floor. This flash

fire developed sufficient heat to ignite the spray materials stored near the booths and also the lacquer residue that had accumulated on the floor near the booths. The employees on the second floor hardly had time to escape, and of the nine employees on the third floor one was burned to death and the others were injured by jumping from the windows. The sprinkler system failed to control the fire, due to an inadequate water supply. The fire department confined the fire to the plant where it originated. Loss $260,000. (S-45130.)

FEBRUARY 24, 1928. PAPER MILL, RUMFORD, ME. Fire occurred in the wood room building. A belt slipped off its pulley and was replaced. A few minutes later it slipped off again and in thrashing around produced a cloud of dust. Simultaneously the metal belt lacing struck a spark and a small dust explosion occurred. Almost immediately there was a sharp report and flames and smoke enveloped the building. Presumably the first minor explosion had dislodged dust throughout the room and the ensuing fire ignited the dust cloud and caused the second and more severe explosion. Although all of the employees had easy access to the exits, the spread of the fire was so rapid that one employee was suffocated and two others were severely burned. Loss $2300. (S-47203.)

Suffocation by Fumes or Smoke.

MARCH 5, 1927. SHOE MANUFACTURING ACCESSORIES, HAVERHILL, MASS. Two men were working in a room containing a considerable quantity of celluloid when a fire of unknown origin occurred. While one of them escaped, the other man tried to extinguish the fire. He was overcome by fumes and lost his life. When firemen, summoned by an automatic alarm, arrived, upon being informed that there was a man inside, they donned gas masks and proceeded to enter the building. Just at this time there was an explosion, slightly injuring several of the firemen. Before they could ventilate the building a more violent explosion occurred, blowing out the windows and severely burning several firemen in the alley outside the building. Although sixteen sprinklers opened, they had little effect on the fire, which was severe. The loss was considerable. (S-44078.)

APRIL 24, 1929. ICE CREAM FACTORY, PITTSBURGH, PA. Fire started in a small unsprinklered ice storage room which was just being completed. Workmen were applying cork insulation to walls and ceiling, using pitch for this purpose, which was being heated by a gas fire in a large portable pitch kettle. Wood scaffolding in the room collapsed from some unknown cause and upset the pitch kettle. Due to the absence of sprinklers in the room, the fire spread rapidly.

At the time of the fire the main elevator shaft was open from the first to the fourth floors and the opening to the shaft on the first floor adjoined the ice storage room. Fire and heat spread rapidly up the shaft and one employee

was trapped in the stock room on the fourth floor by the dense black smoke from the burning pitch and was dead from suffocation when found. Sprinklers operated on each of the upper floors and also in the ice tank room on the first floor, checking the fire. Lack of ventilation throughout the building undoubtedly aided in banking up the heat, particularly on the fourth floor, where approximately forty sprinklers operated. The loss was $37,843. (S-51554.)

Sprinklers Shut Off.

JANUARY 19, 1925. TENANT MANUFACTURING, NEW YORK, N. Y. Fire occurred from an unknown cause in a small cut-off section of the freight hall occupied by a lunch counter. Five sprinkler heads fused, but as the cold weather valve was closed for the winter no water was discharged and no water flow signal was sounded. Finally an outsider discovered the blaze and turned in an alarm through a street box, but by the time the fire department arrived the night watchman at the building had lost his life. He was found dead at the freight hall entrance from the street. Damage consisted chiefly of the destruction of the lunch stand. (S-39768.)

MARCH 9, 1926. TENANT MANUFACTURING, CHICAGO, ILL. Fire starting on the second floor of an eight-story brick semi-mill constructed building totally destroyed the structure. The spread of the fire through the building was rapid, as the sprinkler system had been shut off and the tanks drained due to freezing and rupturing of the piping on the day previous to the fire. One man was burned to death and two others escaped with difficulty. It is reported that proper maintenance of the sprinkler equipment, sub-standard as it was, would have prevented the rapid spread of fire and would have confined the loss to the section where the fire originated. Loss estimated at $700,000. (S-41634.)

Re-entering Burning Building.

MAY 22, 1929. MATTRESS FACTORY, DERRY, N. H. The fire was caused by an arc from an electric motor driving a sewing machine which was located between two mattress forming machines. It is probable that there was considerable loose flammable stock on the floor, over which the fire flashed quickly, opening most of the sprinkler heads on the floor. An elderly woman working on the sewing machine where the fire originated lost her life. She went back to get her coat and belongings and was so seriously burned that she died the next day. The sprinkler system functioned properly, but with some delay due to the dry system, and held the fire in check. The loss was estimated at $30,000. (S-52130.)

Fires in Which There Was a Loss of Life.

These notes are intended to point out typical conditions under which loss of life has occurred that they may be known and guarded against.

As a departure from the conventional tabulation of typical loss of life fires, it was decided to present in this issue of the QUARTERLY a brief summary and analysis of all reports involving loss of life received by the Department of Fire Record since the publication of the last QUARTERLY. The reports on which this record is based are those of fires occurring since May 1, 1930, and while the number of fires reported to the N.F.P.A. is but a small fraction of the total number that have occurred during this period, the volume of data is sufficient to indicate the predominating causes of loss of life.

Many of the reports are based on newspaper accounts. Such reports are almost the only source of data on loss of life by fire, particularly those occurring in other than mercantile or industrial occupancies, and the coöperation of our readers in forwarding to the executive office such reports is requested.

Causes of Loss of Life, May-September, 1930.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

Cause	Lives Lost. Men	Women	Children	Total
Airplane accidents	31	3	0	34
Automobile accidents	7	2	2	11
Candle ignited clothing	0	0	1	1
Children and matches	0	0	13	13
Cleaning with gasoline	0	2	0	2
Clothing ignited from gas stove	0	2	2	4
Dust explosion	4	0	0	4
Explosion in fireworks factory	4	1	3	8
Explosion of illicit still	3	1	2	6
Explosion of mechanic's torch	1	0	0	1
Explosion of gasoline stove or lighting plant	0	0	3	3
Fire fighting	2	0	0	2
Firecrackers—fireworks	3	0	3	6
Ignition of flammable liquids or vapor	9	0	7	16
Kerosene used to start fire	0	1	1	2
Oil lamp or stove	1	2	3	6
Overexertion or excitement induced by fire	0	1	0	1
Railway accident	4	0	0	4
Responding to alarms	6	0	0	6
Re-entering burning building	0	2	0	2
Smoking in bed	1	0	0	1
Trapped in burning building	17	7	18	42
Unknown	5	0	1	6
Total	98	24	59	181

Loss of Life Fires, May-September, 1930.

Class of Fire	No. of Fires	Lives Lost. Men	Women	Children	Total
Airplane accidents	18	31	3	0	34
Automobile accidents	5	7	2	2	11
Apartments, hotels, tenements, etc	8	8	4	2	14
Dwellings—Urban	21	7	7	17	31
Dwellings—Rural	16	4	7	22	33
Industrial occupancies	5	7	1	1	9
Mercantile occupancies	6	10	0	0	10
Other occupancies	5	5	0	4	9
Mining property	1	5	0	0	5
Fires other than buildings	11	4	0	11	15
Responding to alarms	3	6	0	0	6
R.R. accidents	1	4	0	0	4
Total	100	98	24	59	181

Typical Loss of Life Fires.

Automobile Accidents.

BALTIMORE, MD., AUG. 13, 1930. A man and two three-year-old children were burned to death when fire destroyed the automobile in which they were sitting. The fire occurred when the driver lighted a lantern to look into the gas tank. (H-30115.)

FALMOUTH, MASS., AUG. 26, 1930. A young man was burned to death and another fatally burned when the gasoline tank of their automobile exploded after the machine had skidded and struck an iron fence. The accident occurred on a sharp curve during a heavy fog. Neither of the men was able to get out of the car, which was wedged between the fence and a tree. It was impossible for near-by residents to pull them from the wreckage until fire apparatus arrived and the fire was brought under control. (H-30018.)

TANEYTOWN, MD., SEPT. 17, 1930. A traveling salesman lost his life when fire destroyed the machine in which he was riding. Road marks showed that the car struck a rock at the side of the road, overturned twice, and caught fire. The victim was pinned beneath the wreckage and burned to death. It is believed that he fell asleep at the wheel. (H-30113.)

Children and Matches.

LAWRENCE, MASS., AUG. 6, 1930. A six-year-old girl died from the effects of burns received when her clothing caught fire in the yard of her home. She was running along a cement walk when she stepped on a loose match, which ignited. She tripped and fell and her clothes were ignited by the burning match. (L-705.)

DULUTH, MINN., JULY 7, 1930. Two children died in a play fire which they started under the porch of their home. As the fire spread they crawled out, but when the fire spread into the house they became frightened and went back under the porch, where they were burned to death. (L-717.)

WAKEFIELD, MASS., SEPT. 9, 1930. A five-year-old boy was burned to death and his older brother was seriously burned when a small haystack in the yard of their home caught fire. The fire was believed to have been started by the matches with which the boys were playing. (L-746.)

BALTIMORE, MD., SEPT. 13, 1930. Five children were burned, one of them fatally, when a large can of creosote near a bonfire around which they were playing ignited. One of the children thrust a lighted brand into the can and the children's clothing caught fire as the contents of the can burst into flames. (L-747.)

Cleaning with Gasoline.

NYACK, N. Y., SUMMER, 1930. A woman was cleaning clothes with gasoline in the kitchen of her apartment. An explosion and fire occurred, and the woman with her clothing ablaze jumped from the window into a courtyard. She died later in a hospital. It is believed that fumes from the gasoline reached the pilot light of a gas refrigerator in the kitchen and that the explosion and fire resulted. (L-738.)

LYNN, MASS., AUG. 25, 1930. A young woman was burned to death when fumes from gasoline, which she was using to clean clothes in the kitchenette of her apartment, were ignited by the pilot light in the gas stove. The woman's cries attracted occupants of near-by apartments, but they were barred from entering her apartment by a safety chain on the door, until it was too late to prevent the fatal injuries. (L-743.)

Clothing Ignited by Gas Stove.

POUGHKEEPSIE, N. Y., SEPT. 4, 1930. An eight-year-old child was fatally burned when her clothing ignited from contact with a kitchen gas stove. The child had become hungry during the evening and, unknown to her parents, went into the kitchen and lighted the stove with the intention of getting something to eat. When her clothing caught fire she ran out into the yard and before the fire could be extinguished she was fatally burned. (L-735.)

NEW YORK, N. Y., SEPT. 22, 1930. An explosion of escaping gas killed a woman resident of an apartment and caused severe damage to the building. It is believed that escaping gas had been ignited by the pilot light of the gas range in her kitchen. (H-30112.)

Explosion of Gasoline Appliances.

RIVERDALE, KAN., JUNE 26, 1930. Two girls were fatally burned when a gasoline stove exploded. Both girls died the day following the accident. (L-719.)

ASHEVILLE, ALA., JULY 20, 1930. A child was burned to death and two adults received severe burns when a gasoline lamp exploded in a country church. Several other persons received minor injuries in the panic which ensued. About thirty persons were in the building when someone attempted to light one of the burners. As the flame neared the burner there was an explosion, throwing blazing gasoline about the room. (H-30022.)

Firecrackers and Fireworks.

HACKENSACK, N. J., JULY 7, 1930. A four-year-old child was fatally burned when her clothing caught fire from fireworks with which she was playing. Unknown to her parents the child had found the fireworks which had been put away after the holiday and ignited them. (L-732.)

GRAFTON, MASS., JULY 4, 1930. While lighting a sparkler a five-year-old girl received burns from which she died after being taken to the hospital. (L-731.)

FREDERICKSBURG, VA., JULY 4, 1930. A twelve-year-old boy received minor burns when a toy pistol exploded in his hand. At the time of the accident burns were treated, but were considered to be of a minor nature. However, lockjaw developed and the boy was taken to the hospital, where he died a week after the accident. (L-744.)

Ignition of Flammable Liquids or Vapor.

OWENSBORO, KY , JULY 12, 1930. Four boys and a man were killed and three men were seriously burned as the result of an oil well fire. The boys were watching workmen repair a rig after a well had been brought in. Someone near the well lighted a match, which ignited the gas which filled the air about the well. (H-30026.)

ROCK RAPIDS, IOWA, JULY 21, 1930. One man was killed when gasoline fumes, which had accumulated in the basement of the building at a gasoline filling station, exploded. The explosion was due to the ignition of the fumes by a spark from the switch of an automatic air pump. (H-30020.)

STAMFORD, CONN., AUG. 5, 1930. Three men were killed and another was seriously injured when a terrific explosion occurred and damaged four storage buildings in the plant. Fire spread rapidly after the blast, which was believed to have been due to the ignition of alcohol fumes in the dehydrating department by static electricity. (H-30019.)

CAMDEN, N. J., AUG. 7, 1930. A father and son died in the hospital of burns received when a blast wrecked their home. The explosion occurred while the two victims were spraying the walls in their cellar with a solution containing gasoline in order to exterminate sand fleas. (L-745.)

QUINCY, MASS., SEPT. 12, 1930. The night watchman at a garage was fatally burned in a fire which resulted from the ignition of gasoline as the man was filling the tank of a motor truck. He was alone in the garage at the time. The gasoline fumes were thought to have been ignited by a spark struck from the nozzle of the filling hose. The man died before he could be removed from the premises. (H-30117.)